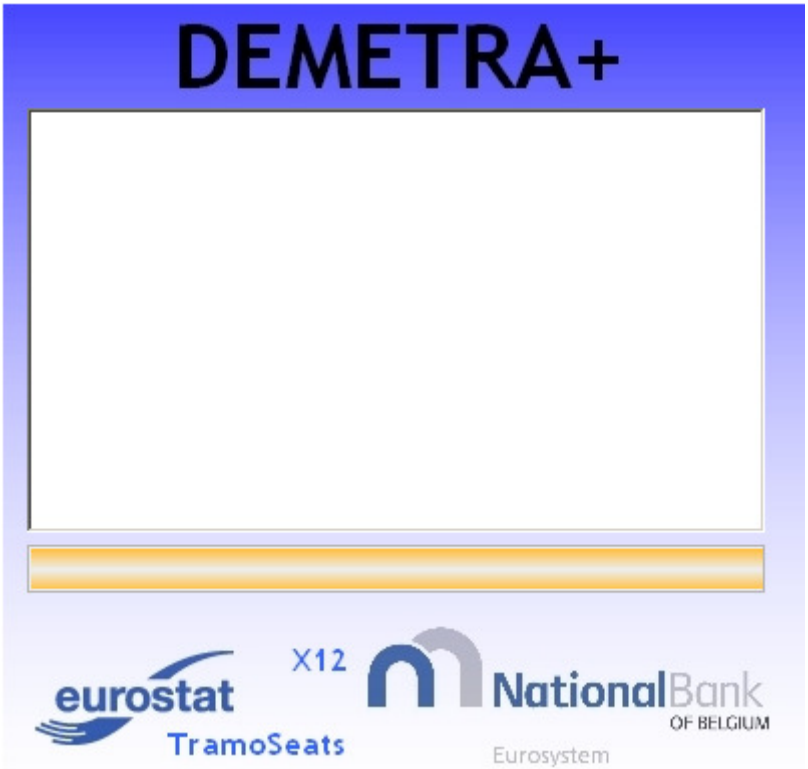
Demetra+

User Manual



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Contents

Contents 3

Introduction 7

1. Basic information 10

1.1. About Demetra+ 10

1.2. Demetra+ application for Microsoft Excel 11

1.3. Uninstall previous version of Demetra+ 12

1.4. Installing Demetra+ 12

1.5. Running Demetra+ 12

1.6. Closing Demetra+ 12

2. Main application's windows 13

2.1. Overview of the software 13

2.2. Browsers 15

2.3. TS Properties 19

2.4. Workspace 19

2.5. Log 21

2.6. Results' panel 22

3. Application's Menu 24

3.1. Workspace menu 24

3.1.1. Calendars 25

3.1.2. User-defined regression variables 29

3.2. Tools menu 30

3.2.1. Container 31

3.2.2. Tool window 34

3.2.2.1. Seasonal chart 34
3.2.2.2. Spectral analysis 35
3.2.2.3. Differencing 36
3.2.2.4. Options 37

3.3. X12 Doc 44
3.4. TramoSeats Doc 45
3.5. Window menu 46
4. Seasonal adjustment 48
4.1. X12 specifications 49
4.1.1. General description 49
4.1.2. Basic 50
4.1.3. Transformation 50
4.1.4. Calendar effects 51
4.1.5. Regression 55
4.1.6. Automatic modelling 59
4.1.7. Arima 60
4.1.8. Outliers detection 62
4.1.9. Estimation 64
4.1.10. Decomposition (X11) 64
4.2. TramoSeats specifications 66
4.2.1. General description 67
4.2.2. Transformation 67
4.2.3. Calendar effects 68
4.2.4. Regression 71
4.2.5. Arima modelling - automatic modelling 74
4.2.6. Arima model 75
4.2.7. Outliers detection 76
4.2.8. Estimation 77
4.2.9. Decomposition (Seats) 78
4.3. Single processing 79
4.3.1. Defining a single-processing 79
4.3.1.1. Creation of a single processing using existing specification 79
4.3.1.2. Creation of a single processing by defining new specifications 82

4.3.2. Seasonal adjustment results – single processing 86
4.3.2.1. X12 88
4.3.2.1.1. Main results 89
4.3.2.1.2. Pre-processing 94
4.3.2.1.3. Decomposition 101
4.3.2.1.4. Diagnostics 104
4.3.2.2. TramoSeats 126
4.3.2.2.1. Main results 127
4.3.2.2.2. Pre-processing (Tramo) 130
4.3.2.2.3. Decomposition 135
4.3.2.2.4. Diagnostics 156
4.4. Multi-processing 157
4.4.1. Defining a multi-processing 157
4.4.2. Seasonal adjustment results for multi-processing 160
4.4.2.1. Generalities 160
4.4.2.2. Multi-processing menu 163
4.4.2.3. Detailed results and modification of the specification 164
4.4.3. Period-to-period data production 168
4.4.4. Further explanations on the refreshing of multi-processing 171
4.4.5. Sending the results to external devices 172
4.4.6. Assigning priority to the series 173
4.5. Additional functions 176
4.5.1. Changing the specification 176
4.5.2. Saving and refreshing workspaces 177
Annex 180
1A Definition of the residuals 180
2A Least squares estimation by means of the QR decomposition 180
3A Specifications 181
4A Model selection criteria 182

5A TramoSeats method 183

6A Initial values for Arima model estimation 191

7A Cancellation of AR and MA factors 191

8A X12 tables 191

9A Spectral analysis 194

10A Revision histories 197

11A Sliding spans 198

12A Tests 199

13A Code to generate simple seasonal adjustments (C#) 205

REFERENCES 207

Introduction

Seasonal adjustment (SA) is an important step of the official statistics business architecture and harmonisation of practices. Since the 1990s, Eurostat has been playing a leading role in the promotion, development and maintenance of an open source software solution for seasonal adjustment in line with established best practices. Developed by Eurostat, Demetra software was intended to provide a convenient and flexible tool for seasonal adjustment using TramoSeats[1] and X-12-Arima[2] methods.

In 2008 the European Statistical System (ESS) guidelines on seasonal adjustment have been endorsed by the Committee on Monetary, Financial and Balance of Payments statistics (CMFB) and the Statistical Programme Committee (SPC) as a framework for seasonal adjustment of Principal European Economic Indicators (PEEIs) and other ESS and ESCB economic indicators. ESS guidelines focus on two most commonly used seasonal adjustment methods, i.e. TramoSeats and X-12-Arima and present useful practical recommendations. Both methods are divided into two main parts. First one is called a pre-adjustment and removes the deterministic effects from the series by means of a regression model with Arima noises. Second one is the decomposition. TramoSeats and X-12-Arima use a very similar approach in the first part of the processing but they differ completely in the second part of the algorithm. Therefore, the comparison of the results is often difficult, even for the modelling step. Moreover, their diagnostics focus on different aspects and their outputs take completely different forms.

Eurostat faced a huge challenge of improving comparability of the results and diagnostics from both methods in existing Demetra, because this software was not flexible enough. Moreover,

1 TramoSeats is a model-based seasonal adjustment method developed by Victor Gomez and Agustin Maravall (Bank of Spain). It consists of two linked programs: Tramo and Seats. Tramo ("Time Series Regression with Arima Noise, Missing Observations, and Outliers") performs estimation, forecasting, and interpolation of regression models with missing observations and Arima errors, in the presence of possibly several types of outliers. Seats ("Signal Extraction in Arima Time Series") performs an Arima-based decomposition of an observed time series into unobserved components. Both programs are supported by Bank of Spain, for more details see GÓMEZ, V., and MARAVALL, A. (2001) or CAPORELLO, G. and MARAVALL, A. (2004).

2 X-12-Arima is a seasonal adjustment program developed by the US Census Bureau. It includes all the capabilities of the X-112 program, which estimates trend and seasonal component using moving averages. X-12-Arima offers useful enhancements including: extend the time series with forecasts and backcasts from Arima models prior to seasonal adjustment, adjustment for effects estimated with user-defined regressors, additional seasonal and trend filter options, alternative seasonal-trend-irregular decomposition, additional diagnostic of the quality and stability of the adjustments, extensive time series modelling and model selection capabilities for linear regression models with Arima errors. X-12-Arima is supported by the US Bureau of Census, for more details see FINDLEY, D. F., MONSELL, B. C., BELL, W. R., OTTO, M. C., CHEN, B-C. (1998).

some ESS Guidelines were not easy to apply using Demetra software. The only effective long-term solution was to create new seasonal adjustment software, namely Demetra+ which covers the recommendation of ESS guidelines in this area.

Demetra+ has been developed by the National Bank of Belgium. The application seasonally adjusts large-scale sets of time series and provides user-friendly tools for checking the quality of the SA results. Demetra+ includes two seasonal adjustment methods: X-12-Arima and TramoSeats. As Demetra+ IT solutions are utterly different from the old Demetra, all files created in Demetra are not read by Demetra+. Demetra is no more developed nor supported by Eurostat.

The manual aims to introduce the user to the main features of the Demetra+ software and to make the user able to take advantage of the powerful tools provided. This document presents an overview of the software capabilities and of its main functionalities. Moreover, step by step descriptions how to solve some basic tasks are included. The User Manual will give the possibilities for reproducing results with user's own data. The guide shows the typical paths to follow and illustrates the user-friendliness of Demetra+. The reader is expected to have already acquired background knowledge about the concept of seasonal adjustment and is familiar with X-12-Arima and TramoSeats methods. For those readers interested in studying the seasonal adjustment methods in detail, bibliography is provided at the end of the manual.

It should be emphasized that Demetra+ makes use of X-12-Arima and TramoSeats algorithms, restricted with regard to their original implementations. For this reason, there are some differences between original programs and programs implemented in Demetra+. The aim was to develop the software which enables the comparison of the result from TramoSeats and X-12-Arima. For this reason, the revision history and the sliding spans analysis are available in Demetra+ both for TramoSeats and X-12-Arima. On the contrary, some functionalities implemented in original programs are missing in Demetra+ (e.g. using X-12-Arima under Demetra+ it is not possible: to do a pre-adjustment of the original series with "prior adjustment factors", to specify Arima model $(p,d,q)(P,D,Q)$ without some lags in the regular part is not possible for the X-12-part in Demetra+[3]).

The User Manual is divided into five parts.

Chapter 1 presents the general features of the software.

In Chapter 2 the application's menu is outlined.

Chapter 3 focuses on the workspace menu and useful options offered by Demetra+. Chapter 4 describes how to define the seasonal adjustment of a single series and large sets of series. The X-12-Arima and TramoSeats specifications are presented. In this part the results of seasonal adjustment as well as their interpretation is discussed. Some theoretical aspects of seasonal adjustment using X-12-Arima and TramoSeats are also included.

3 For example, the user cannot specify the model (2,1,1)(0,1,1) without parameter AR(1).

Selected aspects of seasonal adjustment methods and technical issues are described in the Annex. Instead of "X-12-Arima" Demetra+ uses notation "X12". For this reason this notation is used further in this Manual.

1. Basic information

1.1. About Demetra+

The first release of Demetra+ contains Demetra+ itself (main graphical interface) and Excel add-ins: ColorAnalyser, Demetra+ XL and XL Functions. More information about Excel add-ins is available in 1.2. *Demetra+ Application for Microsoft Excel*.

Demetra+ version 1.0 uses the following core engines:

- TramoSeats dlls, dated 8/2009,
- X12 dll, used in Demetra 2.2.

The most important results (including the complete RegArima model) directly come from the core engines. All the diagnostics are computed outside the core engines (see below).

One of the strategic choices of Demetra+ is to provide common presentation/analysis tools for both TramoSeats and X12. Thus, of that the results from both methods can be easily compared. This implies that many diagnostics, statistics, auxiliary results, etc. are computed outside the core engines. Demetra+ is of course highly influenced by the output of TramoSeats and of X12. Most analyses presented in Demetra+ are available in the core engines. However, the results with TramoSeats and X12 may slightly differ for a lot of reasons (different statistical/algorithmic choices, possible bugs). In any case the global messages of seasonal adjustment are (nearly) always similar.

Amongst the most important tools implemented in Demetra+, the following functionalities should be mentioned:

- Likelihood (X12-like) / RegArima model (t-stat as in Tramo): RegArima model was re-computed in Demetra+ (X12, Tramo and "Stamp-like" solutions available in the framework),
- Residuals analysis (Tramo-like, but based on another set of diagnostics),
- Seasonality tests (X12-like),
- Spectral analysis (X12 definition),
- Sliding spans (X12),
- Revision history,
- Wiener-Kolmogorov analysis (Seats-like).

Solutions implemented in Demetra+ lead to more flexible software. New features are easy to add to the software without modifying the core engine. One of the key features of Demetra+ is the possibility to use the underlying algorithms through a rich application programming interface (API). This feature allows the integration of the routines in very different contexts as well as the building of new applications. The most important concepts (time series, seasonal adjustment...) developed to encapsulate the core engines are common to both algorithms. The code for making

basic seasonal adjustment is straightforward. However, it is possible to use the API to solve very tricky problems. A minimalist example is provided in the Annex (section 13A).

Amongst the peripheral services offered by Demetra+, the following ones should be stressed:

- Dynamic access to various "time series providers": Demetra+ provides modules to handle time series coming from different sources: Excel, databases (through ODBC), WEB services, files (text, TSW, USCB, xml, SDMX...); the access is dynamic in the sense that time series are automatically refreshed by the software, which consults the providers to download new information. The model allows asynchronous treatment.
- Common xml formatting: the seasonal adjustment processing can be saved in xml files, which could be used to generate, for instance, WEB services around seasonal adjustment.

The software was designed to allow the adding of new modules without modifying the core application. The main features that can be enriched are listed below:

- Time series providers: the users could add their own modules to download series coming from other databases,
- Diagnostics on seasonal adjustment,
- Output of SA processing.

As mentioned above, the API could be used to generate completely independent applications, but also to create more easily extensions to the current application.

Demetra+ is compatible with Windows XP, Windows Vista and Windows 7. Although Demetra+ is a 32 bits application, it also works with 64 bits version of operating system.

1.2. Demetra+ application for Microsoft Excel

A Demetra+ application for Microsoft Excel is attached to the stand alone Demetra+. The applications are called Excel-add-ins.

The aim of this tool is to provide, in the Microsoft Excel environment, a seasonal adjustment tool inspired from the Demetra+ stand alone application. The application is designated for efficient multiprocessing, hence information about quality is limited in comparison to Demetra+. Using Excel add-ins the user can easily and quickly calculate the seasonal adjustment for a whole table of time series in the frame of an Excel workbook with detailed results for each series in separate worksheets. Both TramoSeats and X12 methods are available.

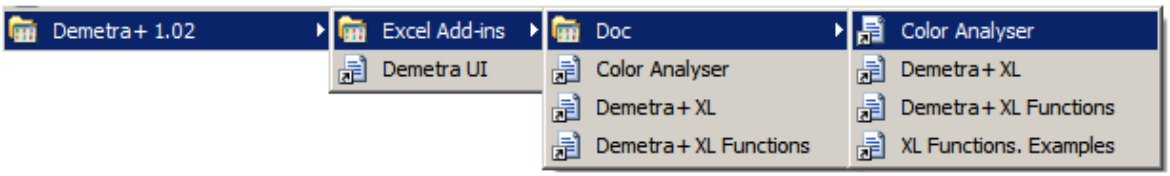
The Demetra+ application for Microsoft Excel is delivered as a usual workbook in two versions, one for the Excel 2003 (Demetra+.xls) and one for Excel 2007 (Demetra+.xlsm). The workbook contains only the application code in VBA. The code structure is available for users.

Demetra+ application for Microsoft Excel consists of:

- ColorAnalyser (a tool to search outliers in an Excel worksheet containing time series),

- Demetra+ XL (a seasonal adjustment tool in the Microsoft Excel environment, inspired by the Demetra+, which can be used for multiprocessing),
- XL Functions (Set of Demetra+ Excel functions).

Manuals for applications are attached to the software. The picture below shows how to find them.



1.3. Uninstall previous version of Demetra+

In order to remove previously installed Demetra+ version, the user should take the following steps:

- Open the "Add/Remove Programs" function in the control panel,
- Uninstall Demetra+ if listed,
- Close the "Add/Remove Programs" function,
- Delete the Demetra+ home directory,
- Delete the program group/icons (if manually created).

1.4. Installing Demetra+

Execute the file "setup" and follow the instructions on the screen. Always take the default options, i.e. typical installation etc.

1.5. Running Demetra+

Start working with Demetra+, run the application via the newly installed Windows option under Programs, or start the Demetra.exe file directly from the Demetra sub-folder.

1.6. Closing Demetra+

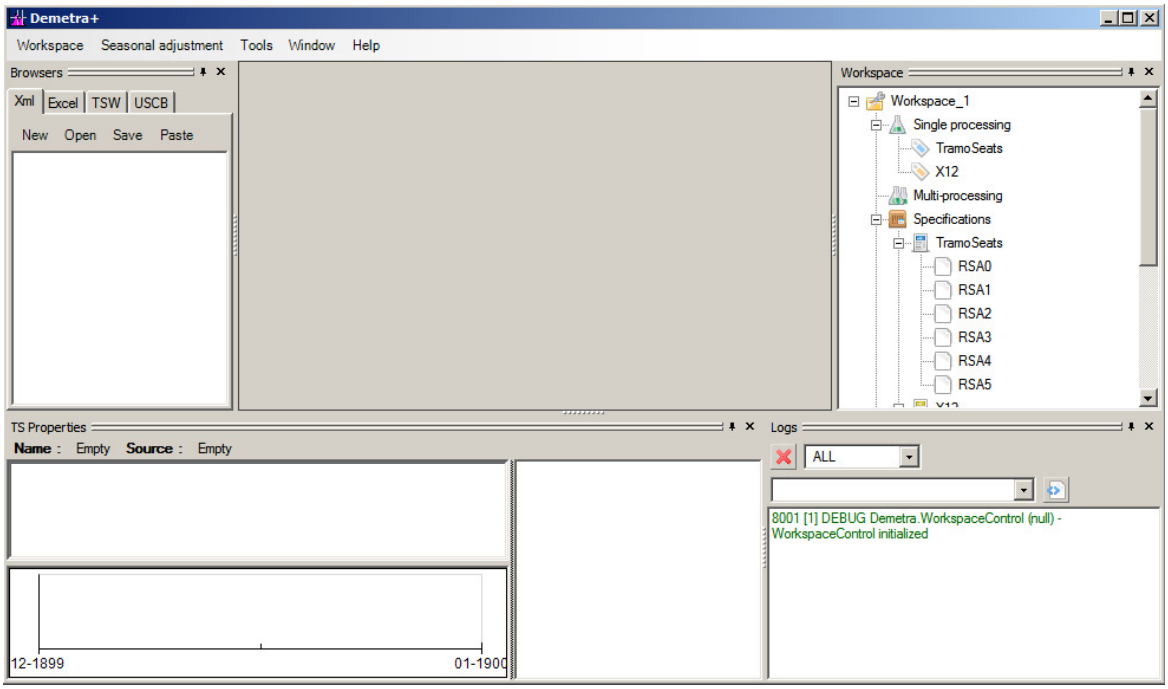
In order to close the application, the user can select File/Exit from the main menu (See Chapter 2). The other way is to click on the close box in the upper right-hand corner of the Demetra+ window,

If you have created any unsaved work, Demetra+ will display a warning and provide you with the opportunity to save it.

2. Main application's windows

2.1. Overview of the software

The main Demetra+ window which is displayed after launching the program is clearly divided into several panels.



The key parts of the application are:

- the browsers panel (left panel), which presents the available time series,
- the workspace panel (right panel), which shows information used or generated by the software,
- a central blank zone that will contain actual analyses,
- two auxiliary panels at the bottom of the application; the left one (TSProperties) contains the current time series (from the browsers' panel) and the right one (Logs) contains logging information.

Those areas will be described in the next paragraphs.

Panels can be moved, resized, superposed and closed[4] depending on user's needs. The presentation is saved between different sessions of Demetra+.

The application can contain multiple documents. Depending on the preferences, the user can present them in different tabs taking the full space (default) or in floating windows (choose this one to follow different steps). The main menu item *Window* gives access to that functionality[5].

4 Closed panels can be re-opened through the main menu commands: Workspace->View->...

Time series can be dragged and dropped between windows (next section presents how to do it). This function is omnipresent in Demetra+, i.e. it is the usual way to move information between different components. The objects that can be moved (e.g. time series, collections of time series) can take different forms: nodes in trees, labels in lists, headers in tables, lines in charts etc.

When a drag and drop operation is initiated (which means that an object is indeed "moveable"), the cursor of the mouse changes to either a "no parking sign" or to a "+ sign". The second one indicates an acceptable drop zone.

Time series from Excel can easily be integrated in Demetra+. The users can import their own data sets. The series must be formatted in Excel as follows:

- True dates in the first copied column,
- Titles of the series in the corresponding cell of the first row,
- Empty top-left cell [A1],
- Empty cells in the data zone correspond to missing values (missing values can appear in the time series except the beginning and at the end of the series).

This format corresponds with the format used by the Excel browser (which also requires the input zone to start at the beginning of the sheet [A1]). The exemplary file is presented below:

	A	B	C	D
1		Currency	M1	M3
2	31-Dec-96	67865,98	140428,8	23563,88
3	31-Jan-97	63680,53	139384,1	22852,73
4	28-Feb-97	63625,74	141692,2	23513,54
5	31-Mar-97	65497,84	144931,6	24591,24
6	30-Apr-97	66635,33	148012,8	25873,43
7	31-May-97	69033,24	151700,6	25934,04
8	30-Jun-97	71672,27	154747,6	26835,17
9	31-Jul-97	74386,61	160454,2	27841,01
10	31-Aug-97	74328,59	162408,5	27907,99
11	30-Sep-97	74658,3	165037	27630,6
12	31-Oct-97	74854,52	170176,5	27663,32
13	30-Nov-97	75283,86	173413,4	27694,36
14	31-Dec-97	79239,77	179602,4	27255,87
15	31-Jan-98	73597,48	178239,7	26487,78
16	28-Feb-98	74417,05	180850,5	27403,85
17	31-Mar-98	75621,69	183236,3	27286,09
18	30-Apr-98	75681,04	185907,5	28834,44
19	31-May-98	78728,63	191080,2	28860,73

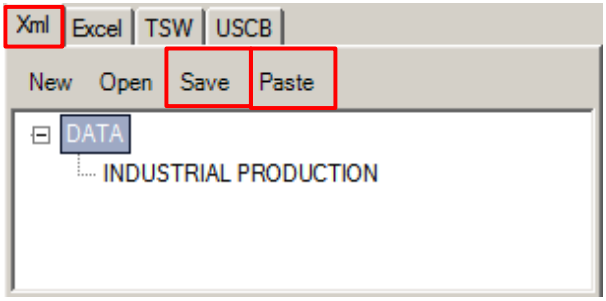
Time series are identified by their names. Demetra+ derives information like data periodicity, starting and ending period from the first column.

After they have been marked and copied in Excel, the data can be integrated in Demetra+ as follows:

- Select the *Xml* panel in the browsers,

5 Refer to Chapter 3.5 for detailed description of this functionality.

- Paste the data (they appear in the tree). This option doesn't work if some files were previously opened via *Xml* browsers. In this case, select the button **New** first and then **Paste**,
- Change the names of the series/collection in the tree if necessary (click twice on the item you would like to modify),
- Save the file (if need be).



Demetra+ is compatible with Excel 2003 and Excel 2007.

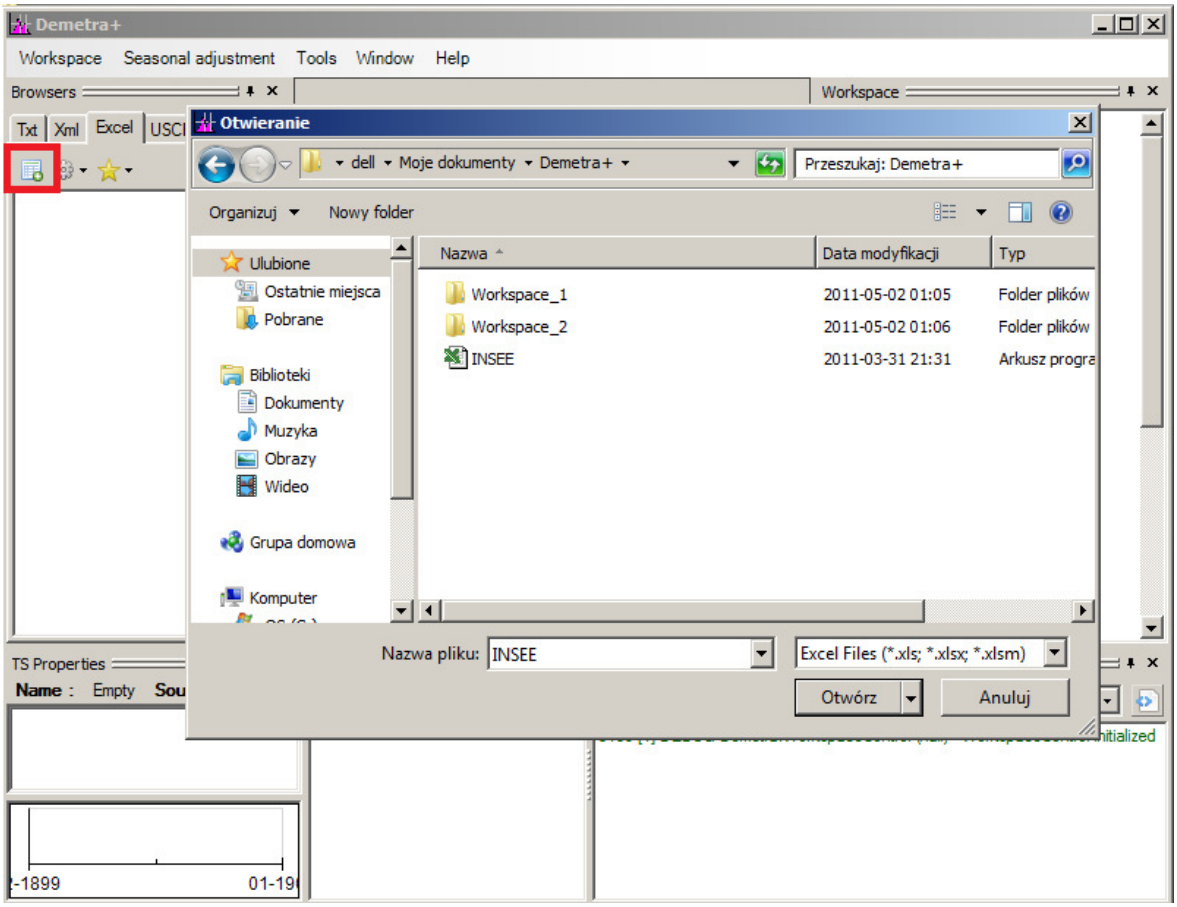
2.2. Browsers

The browsers' panel presents the series available in the software.

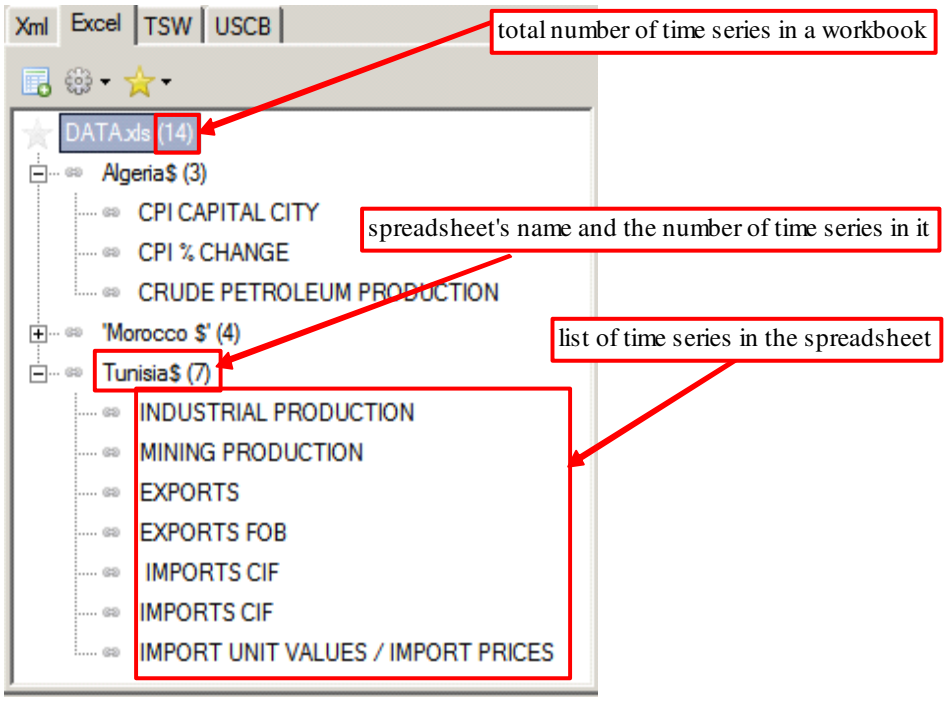
Different "time series providers" are considered: Xml (specific schema), Excel, TSW, USCB, Text and ODBC.

The installation procedure has copied several files in different formats in the subfolders of "My Documents\Data". The method of opening Excel workbooks is presented below. The procedure is similar for the other providers.

1. Click on the Excel tab of the browsers panel,
2. Click on the left button (see below),
3. Choose an Excel workbook (for instance "INSEE.xlsx", see screen below).



Final nodes of the trees represent time series and their parents represent collections of time series. Those nodes correspond with spreadsheets' names. Different browsers show the data in trees that can be expanded by double-clicking their nodes (or single-clicking the "+/-" signs). The tree shows not only how the time series were organized in Excel's workbook, but also how many series are in the whole workbook and in each particular spreadsheet.

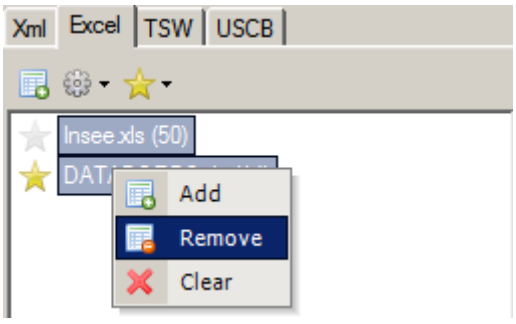


Right click on any time series name opens the pop-up menu, which contains the following commands: **Add**, **Remove**, **Clear**.

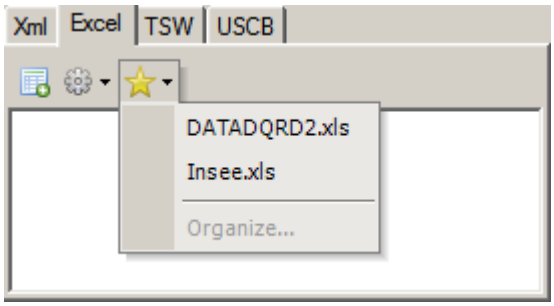
Add – opens new time series set from the Excel workbook,

Remove – removes all time series from the workbook. The button is active only if the name of the workbook is marked. It is not possible to remove all workbooks at the same time,

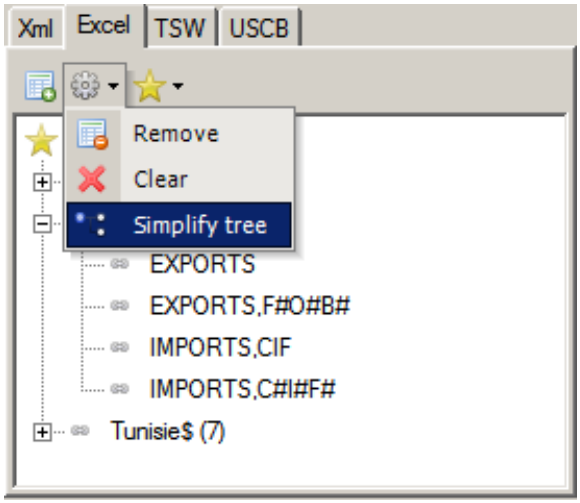
Clear – cleans the browsers' window.



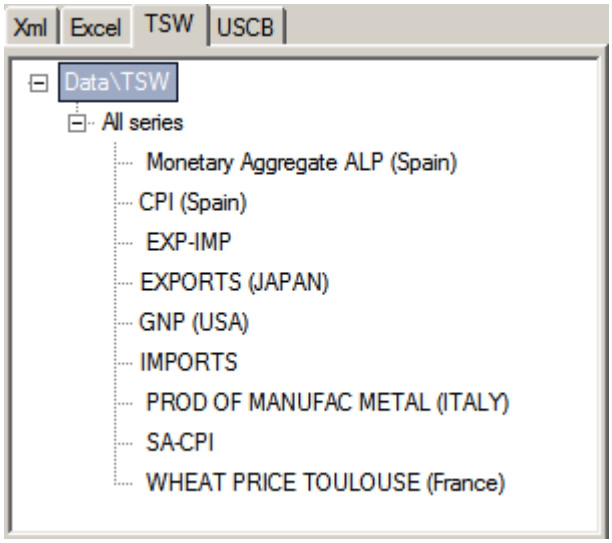
If the user wants to put the workbook into cash memory one should activate the star next to the Excel's workbook name. The list in the *Star* menu contains all workbooks, which are currently in the cash memory.



Using the *Tool* icon (see below) one can remove marked item or clear the window. The **Simplify tree** option collapsed tree with opened branches.



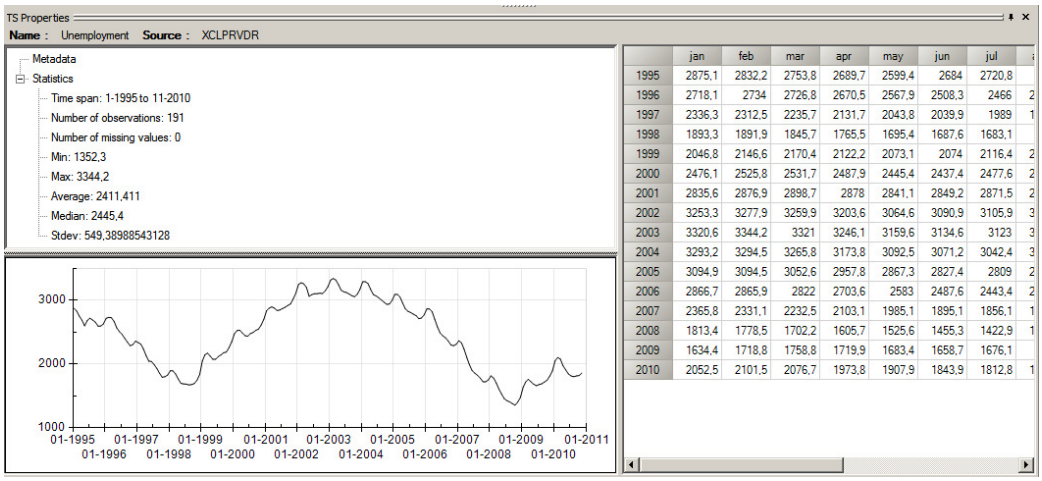
Demetra+ reads files written for TSW. The TSW folder can contain several levels of sub-folders with TSW files. They will appear in the tree navigator of the TSW provider. The series in a subfolder will be grouped in a collection called *All series*. The same idea was applied for USCB source.



2.3. TS Properties

The *TS Properties* window (an abbreviation from Time Series Properties) can be used for examining the characteristics of individual raw series. This panel is strictly connected with *Browsers*. The window is presented at the bottom part of the picture below.

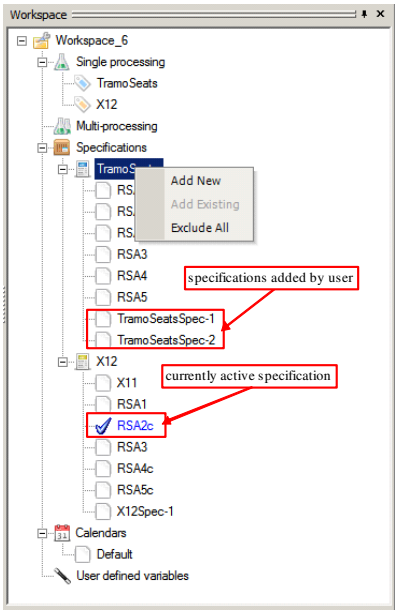
TS Properties window presents the basics statistics, chart and time series data. The function is launched by single clicking on the time series name in *Browsers* window. *TS Properties* provides also information about the name and source of the time series displayed in it.



	jan	feb	mar	apr	may	jun	jul
1995	2875,1	2832,2	2753,8	2689,7	2599,4	2684	2720,8
1996	2718,1	2734	2726,8	2670,5	2567,9	2508,3	2466
1997	2336,3	2312,5	2235,7	2131,7	2043,8	2039,9	1989
1998	1893,3	1891,9	1845,7	1765,5	1695,4	1687,6	1683,1
1999	2046,8	2146,6	2170,4	2122,2	2073,1	2074	2116,4
2000	2476,1	2525,8	2531,7	2487,9	2445,4	2437,4	2477,6
2001	2835,6	2876,9	2898,7	2878	2841,1	2849,2	2871,5
2002	3253,3	3277,9	3259,9	3203,6	3064,6	3090,9	3105,9
2003	3320,6	3344,2	3321	3246,1	3159,6	3134,6	3123
2004	3293,2	3294,5	3265,8	3173,8	3092,5	3071,2	3042,4
2005	3094,9	3094,5	3052,6	2957,8	2867,3	2827,4	2809
2006	2866,7	2865,9	2822	2703,6	2583	2487,6	2443,4
2007	2365,8	2331,1	2232,5	2103,1	1985,1	1895,1	1856,1
2008	1813,4	1778,5	1702,2	1605,7	1525,6	1455,3	1422,9
2009	1634,4	1718,8	1758,8	1719,9	1683,4	1658,7	1676,1
2010	2052,5	2101,5	2076,7	1973,8	1907,9	1843,9	1812,8

2.4. Workspace

Workspace panel organizes all specifications as well as processing and variables defined by the user. In the specification section some specifications are already defined. The user can add new specifications by choosing **Add New** from the pop-up menu (right click on the seasonal adjustment method's name). In *Workspace* panel the user can also define calendars and regression variables. The windows in which the user can define or change the seasonal adjustment parameters, calendars and regression variables will be described in Chapter 3.



Right click on any existing name opens the pop-up menu, which contains the following commands: **Open**, **Exclude**, **Delete**, **Clone**, **Active**.

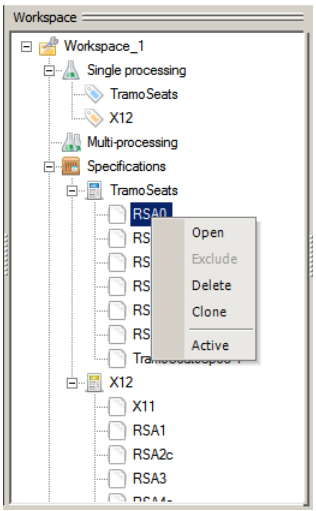
Open – opens the specification window with information on parameters. The user can't change them. The same result is achieved by double click on the specification's name,

Exclude – remove the specification marked. It works only for specifications defined by the user,

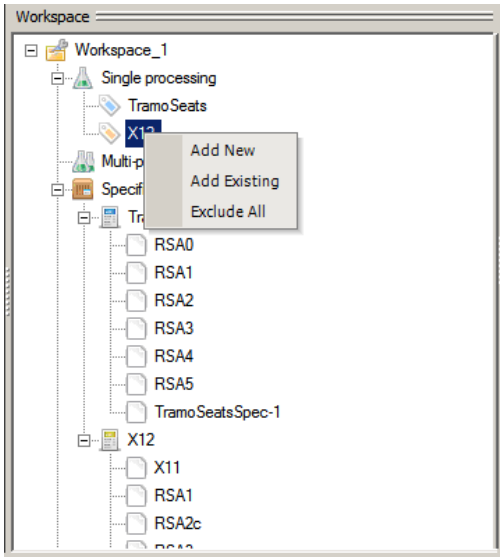
Delete – remove the specification marked. It works only for specifications defined by the user,

Clone – creates new specification, identical with the marked one. The parameters of the newly created specification can be edited by the user,

Active – activates the chosen specification. Time series will be seasonally adjusted using this specification.

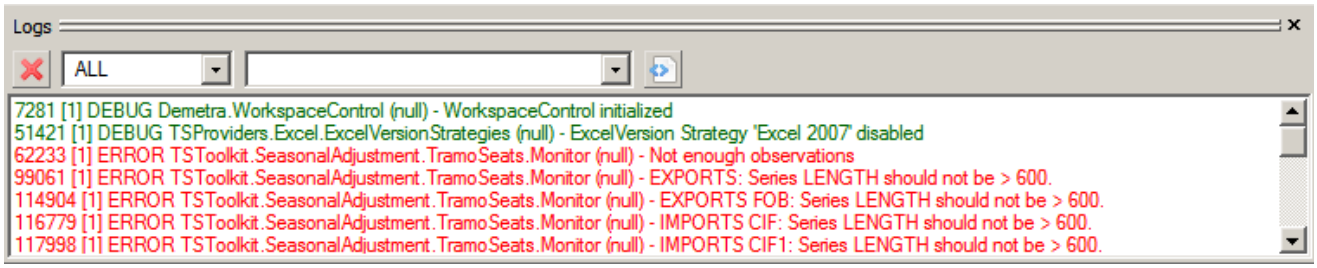


In a similar way the user can add a new specification in single processing and multi-processing sections. This can be achieved by right-clicking on the seasonal adjustment method.

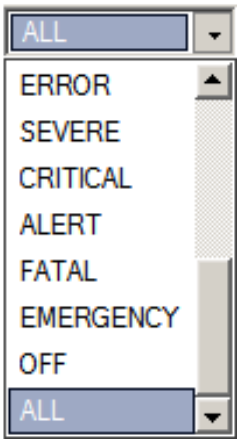


2.5. Log

Log window contains information about all bugs, warnings and other events that took place during session.

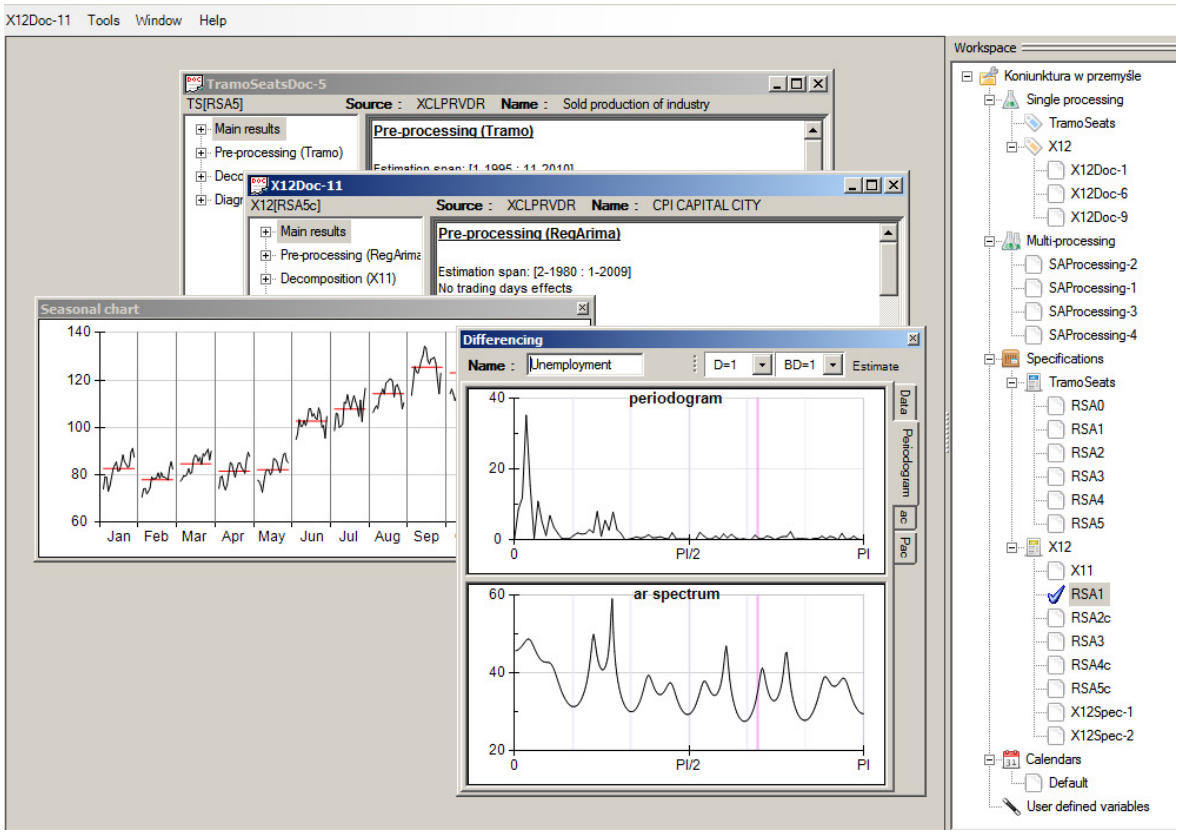

Logs
ALL
7281 [1] DEBUG Demetra.WorkspaceControl (null) - WorkspaceControl initialized
51421 [1] DEBUG TSProviders.Excel.ExcelVersionStrategies (null) - ExcelVersion Strategy 'Excel 2007' disabled
62233 [1] ERROR TSToolkit.SeasonalAdjustment.TramoSeats.Monitor (null) - Not enough observations
99061 [1] ERROR TSToolkit.SeasonalAdjustment.TramoSeats.Monitor (null) - EXPORTS: Series LENGTH should not be > 600.
114904 [1] ERROR TSToolkit.SeasonalAdjustment.TramoSeats.Monitor (null) - EXPORTS FOB: Series LENGTH should not be > 600.
116779 [1] ERROR TSToolkit.SeasonalAdjustment.TramoSeats.Monitor (null) - IMPORTS CIF: Series LENGTH should not be > 600.
117998 [1] ERROR TSToolkit.SeasonalAdjustment.TramoSeats.Monitor (null) - IMPORTS CIF1: Series LENGTH should not be > 600.

The user can also display messages which belong to a chosen category (like ERROR, EMERGENCY, etc).



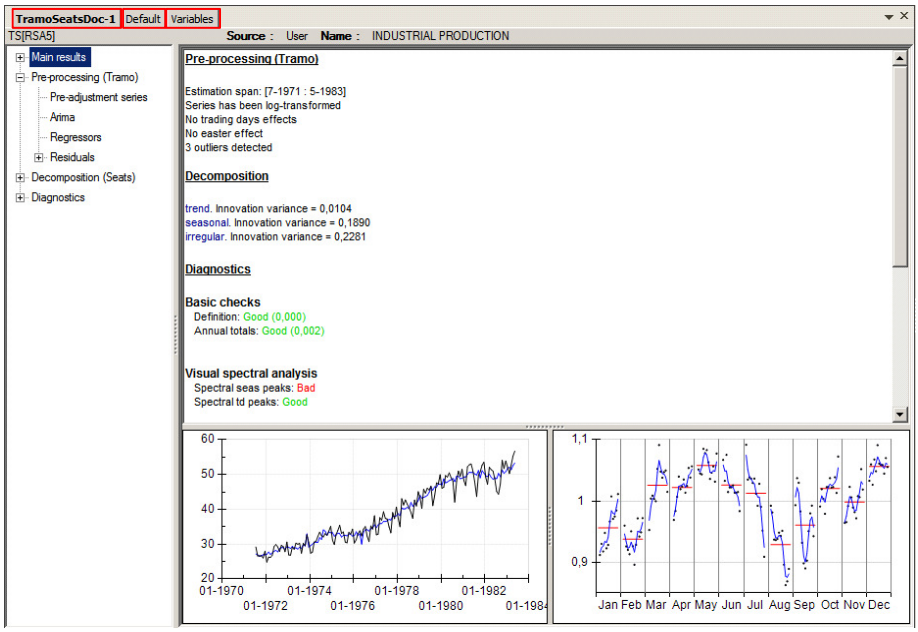
2.6. Results' panel

The panel in the middle of the window is the place where Demetra+ displays the various object windows that it creates. There could be displayed more than one window. Those windows will overlap each other with the foremost window being in focus or active. The active window has a darkened title bar.



The windows in the results' panel can be arranged in many different ways, depending on the user's needs (see 3.5). The example below shows one of the possible displays of this panel. The right part of the panel presents navigation tree while on the left the actual results are displayed.

The user can execute several seasonal adjustments and define some regression variables. The results are displayed in consecutive bookmarks, which allow the user to switch them over. On the picture below it is shown that tree panels are opened - window containing seasonal adjustment results ("TramoSeatsDoc-1"), default calendar ("Default") and user defined variables ("Variables").


TramoSeatsDoc-1
Default
Variables
TS[RSA5]
Source : User Name : INDUSTRIAL PRODUCTION
Main results
Pre-processing (Tramo)
Pre-adjustment series
Arima
Regressors
Residuals
Decomposition (Seats)
Diagnostics
Pre-processing (Tramo)
Estimation span: [7-1971 : 5-1983]
Series has been log-transformed
No trading days effects
No easter effect
3 outliers detected
Decomposition
trend. Innovation variance = 0,0104
seasonal. Innovation variance = 0,1890
irregular. Innovation variance = 0,2281
Diagnostics
Basic checks
Definition: Good (0,000)
Annual totals: Good (0,002)
Visual spectral analysis
Spectral seas peaks: Bad
Spectral td peaks: Good
60
50
40
30
20
01-1970
01-1972
01-1974
01-1976
01-1978
01-1980
01-1982
1,1
1
0,9
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

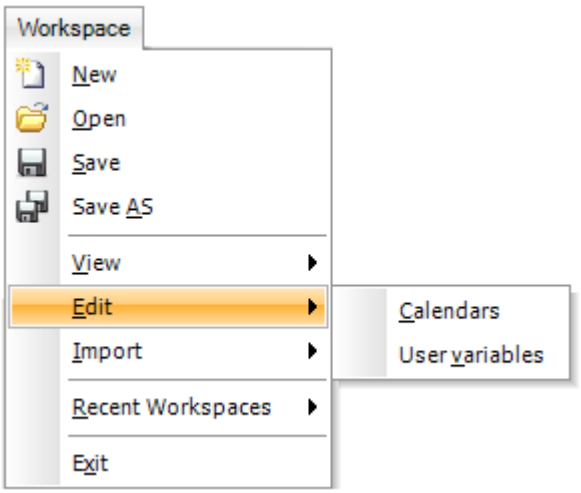
3. Application's Menu

The application's menu is situated at the very top of the main window. If the user moves the mouse's cursor to an entry in the main menu and click on the left mouse button, a drop-down menu will appear. Clicking on an entry in the drop-down menu selects the highlighted item. The functions available in application's menu are described in the paragraphs below.

3.1. Workspace menu

The Workspace menu offers the following functions:

- **New** – creates new Workspace displayed in the right panel,
- **Open** – opens an existing project in a new window,
- **Save** – save the project file named by the system under the name *Workspace_#number* that can be re-opened at a later point in time,
- **Save as** – save the project file named by the user that can be re-opened at a later point in time,
- **View** – activates or deactivates the panels chosen by user (Browsers, Workspace, Logs, TS Properties),
- **Edit** – allows defining countries' calendar and regression variables (this functionality is described further into this instruction),
- **Import** – allows importing countries' calendar and regression variables from Xml files (this functionality is described further into this instruction),
- **Recent Workspaces** – opens workspace recently saved by user,
- **Exit** – closes an open project.



3.1.1. Calendars

This functionality is helpful for detecting and estimating the trading day effects. Trading day effects are those parts of the movements in the time series that are caused by different number of the weekdays in calendar months (or quarters, respectively). As with seasonal effect, it is desirable to estimate and remove trading day effects from the time series. Trading day effects arise as the number of occurrences of each day of the week in month (quarter) differs from year to year. The special case of the calendar effects is a leap year effect, which cause regular variation because of the extra day inserted into February every four years. These differences cause regular effects in some series. Both X12 and TramoSeats estimate trading day effects by adding regressors to the equation estimated in the pre-processing part (RegArima or Tramo, respectively). Regressors mentioned above are generated on calendar basis.

The calendars of Demetra+ simply correspond to the usual trading days contrasts variables based on the Gregorian calendar, modified to take into account some specific holidays. Those holidays are handled as "Sundays" and the variables are properly adjusted to take into account long term mean effects.

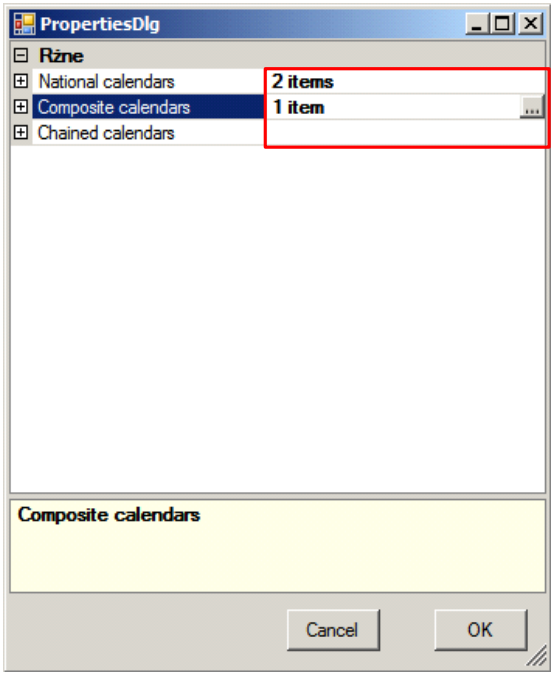
Demetra+ considers three kinds of calendars:

- National calendars, identified by specific days,
- Composite calendars, defined as weighted sum of several national calendars[6],
- Chained calendars, defined by two national calendars and a break date.

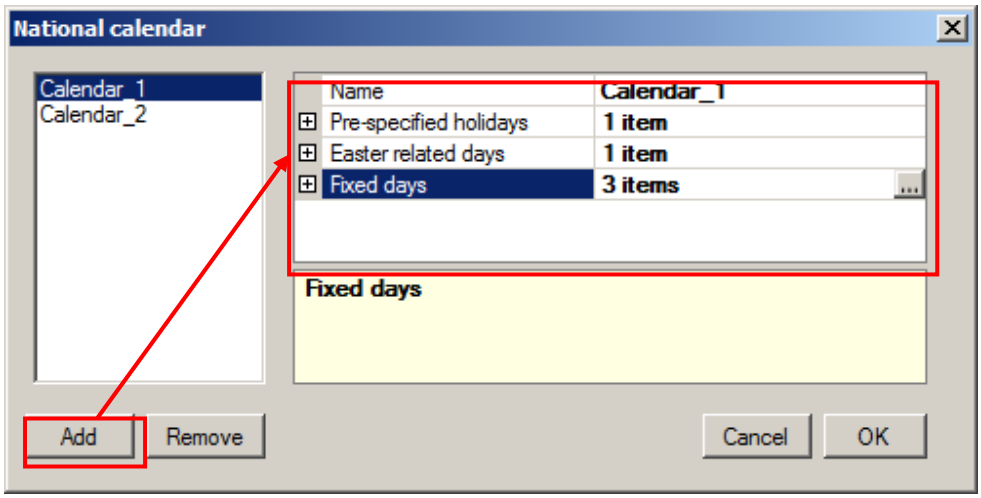
The calendars can be defined recursively. It is also possible to define calendar using User defined regressors.

The dialog box allows defining all calendars described above. In the column on the right the number of calendars already defined is shown.

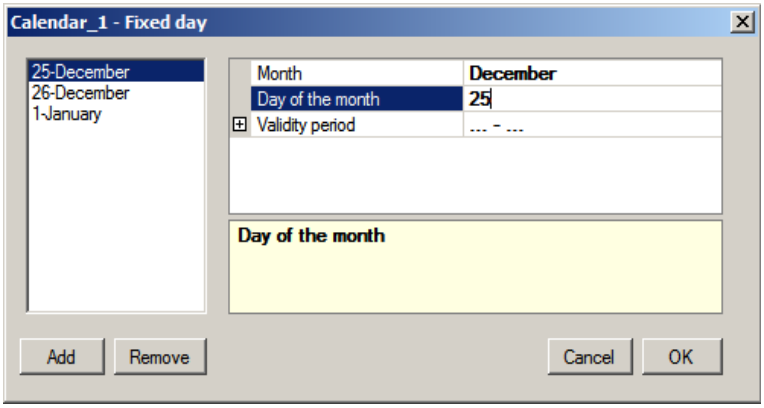
6 The user can also use default calendar to define composite calendar and chained calendar.



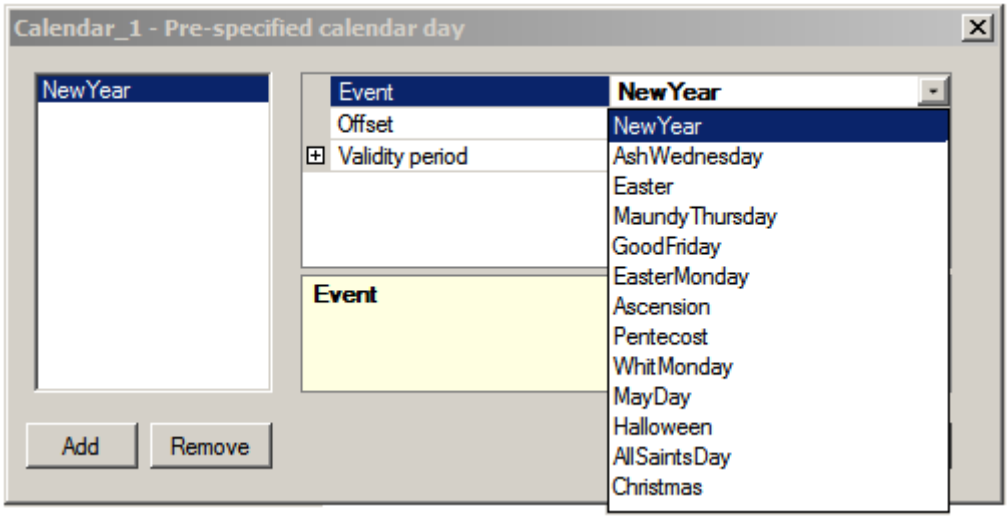
If the user chooses the option **National calendars** the following window is displayed. The user can define new calendar (**Add** button) or modify existing one. The list on the left contains all national calendars defined by the user. In the panel on the right the user could specify the successive parameters.



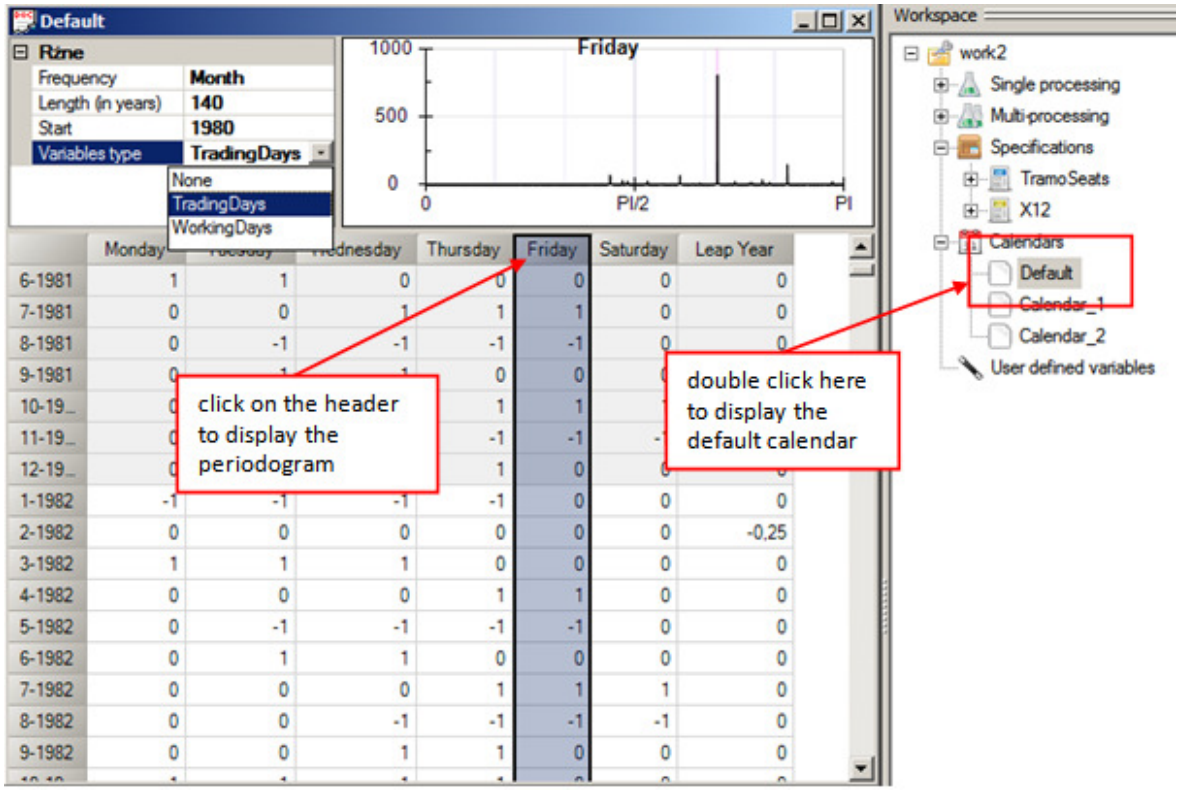
In the example below it is shown how to define fixed holidays (choosing the month from the list and specifying the appropriate day of the month). If the validity period hasn't been specified, the regressor will be applied for all time series span.



Demetra+ offers the following list of pre-specified holidays:



The data generated by each calendar can be viewed by a double click on the corresponding item in the workspace tree.



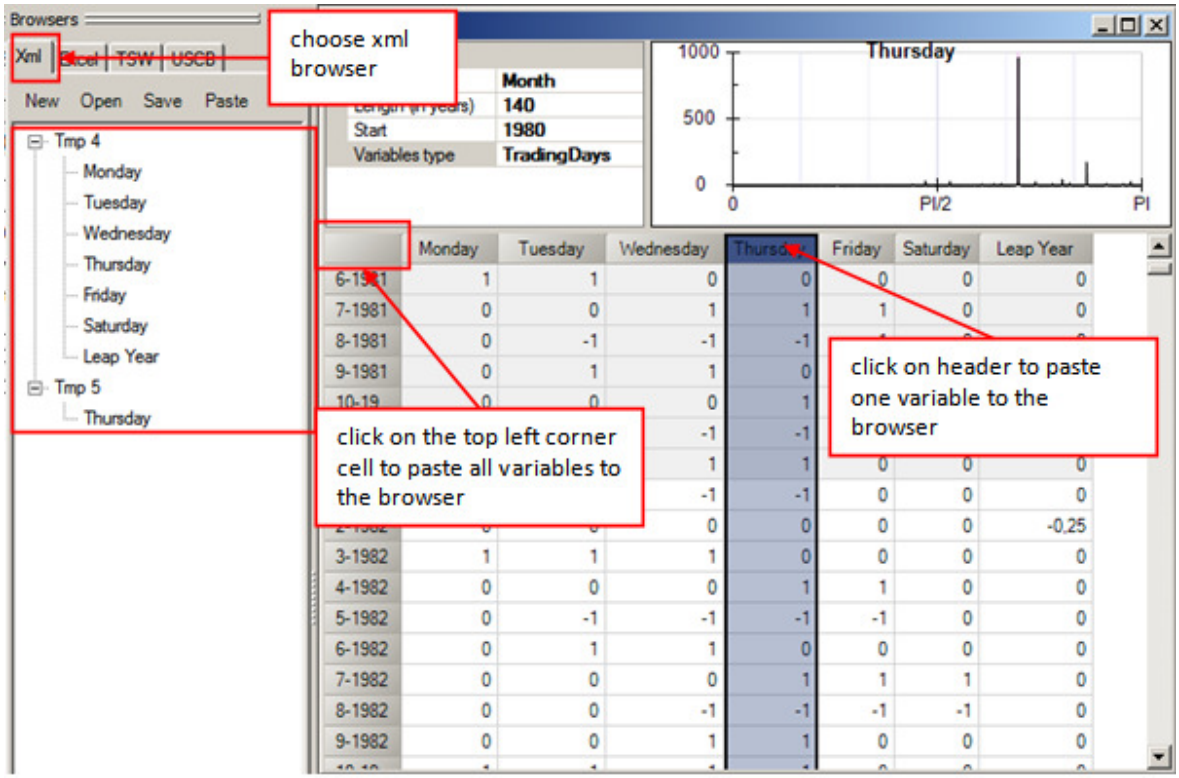
The regression variables can be inspected for any frequency (monthly, bi-monthly, quadri-monthly, quarterly, half-monthly, yearly) and any (reasonable) time span through that window. The periodogram of those series is displayed when a column is selected.

Demetra+ presents three different views:

- Trading Days – seven regression variables which correspond to differences in economical activity between all days of the week and leap year effect,
- Working Days – two regression variables which correspond to differences in economical activity between the working days (Monday to Friday) and non-working days (Saturday - Sunday) and the leap year effect,
- None – one regression variable which corresponds to the leap year effect.

This window should be used to analyze the data created by the calendar. Actually, Demetra+ enables the user to include/exclude the leap year effect from the seasonal adjustment model (see 4.1.3.1 and 4.2.2.1).

The series can be copied by drag and drop as it is shown in the picture below. The local menu can be used to copy and paste the series to other applications (e.g. Excel).



Calendars defined by the user are added to the *Workspace tree*. The user can display, edit or add new calendar by clicking on *Calendars* in *Workspace tree* and choosing appropriate option from the pop-up menu (for more details see: 2.4 *Workspace*).

3.1.2. User-defined regression variables

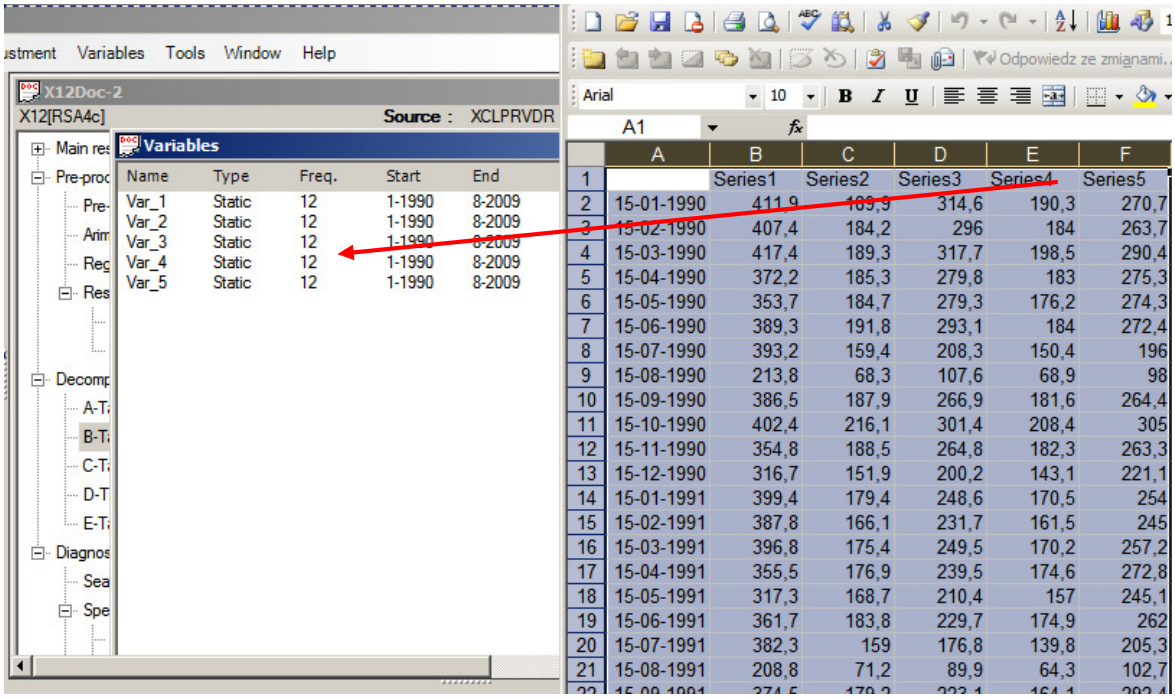
User-defined regression variables are simply time series identified by their name. Those names will be used in other parts of the software (regression) as identifier of the data.

Demetra+ considers two kinds of user-defined regression variables:

- Static variables, usually imported directly from external software (by drag and drop or copy - paste),
- Dynamic variables, coming from files opened with the browsers.

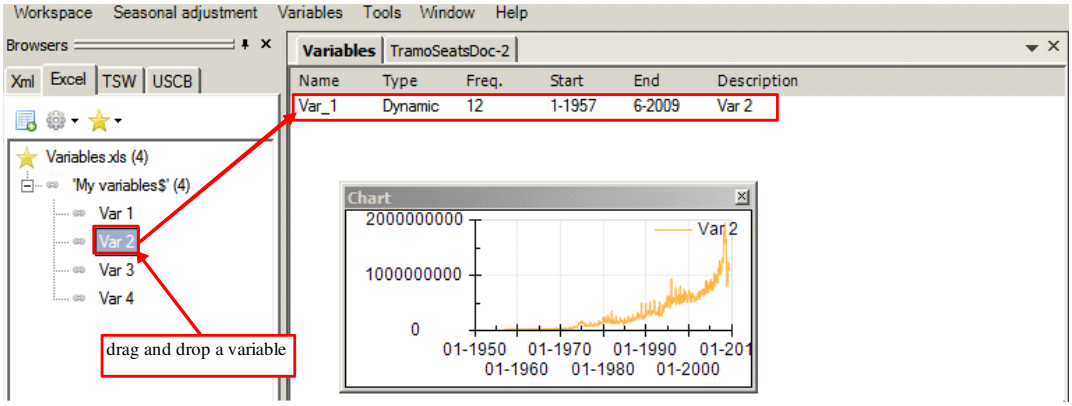
It should be emphasized that Demetra+ works on the assumption that a user-defined regressor is already in an appropriately centered form (i.e. the mean of each user-defined regressor is subtracted from the regressor or means for each calendar period (month or quarter) are subtracted from each of the user-defined regressor).

Static variables imported directly from external software (for instance Excel) must be formatted as defined in the *Importing data from Excel* section. To import them, select from *Workspace* menu *Import* item and then *User variables* (or double click item *User defined variables* in the Workspace tree) and by drag and drop time series from Excel or use the usual keys (*ctrl-c* and *ctrl-v*).



The figures of static variables cannot be changed. Currently, the only way to update static series consists in removing them from the list and to re-import them with the same names as previously.

Dynamic variables are imported by drag and drop series from a browser of the application.



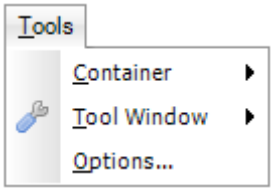
Names of the series can be changed by selecting a series and clicking once again when it has been selected. The selected series can be displayed in a small chart window by a double click on regressor's name. Dynamic variables are automatically updated each time the application is re-opened. Therefore, it is a convenient solution for creating user-defined variables.

3.2. Tools menu

The Tools menu is divided into tree parts:

- **Container** – tools for displaying data,
- **Tool Window** – charts and data transformation,

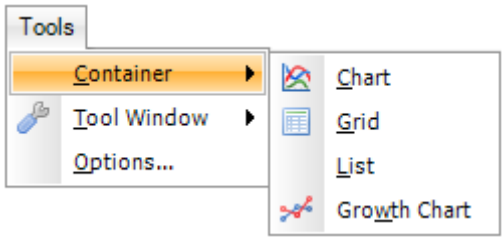
- **Options** – different windows, diagnostic and output options that can be set by user.



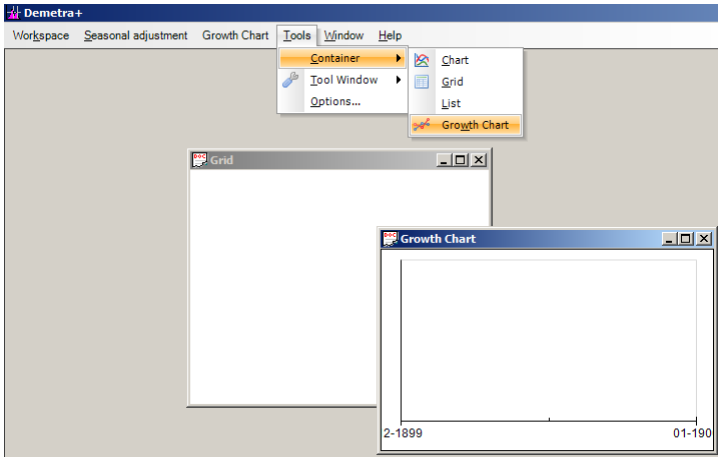
Be advised that the current implementation is not able to detect recursive processing. An attempt to do so will generate a crash of Demetra+. The example of recursive processing is to select the series "D11" from X12 window and drop the series "D11 into the same X12 window from which "D11" was selected.

3.2.1. Container

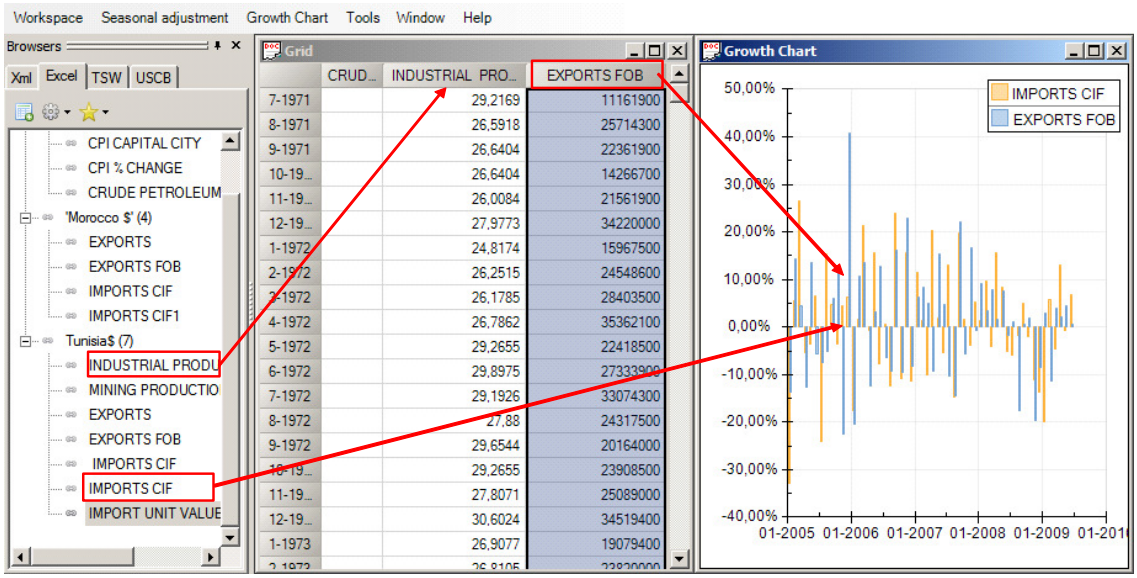
Container includes helpful tools to display the data. The following options are available: **Chart**, **Grid**, **List** or **Growth Chart**.



At first, the user should choose one or few containers from menu.

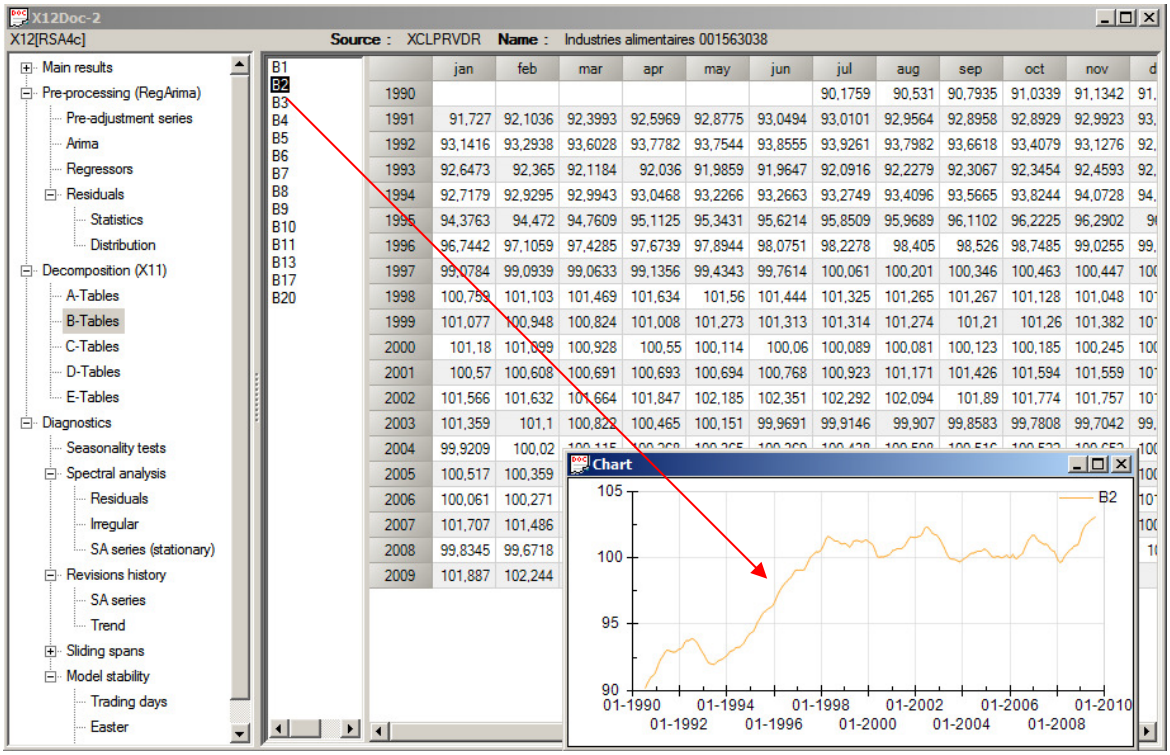


Then the user can take any series or group of series from one of the browsers and drop it in a container.

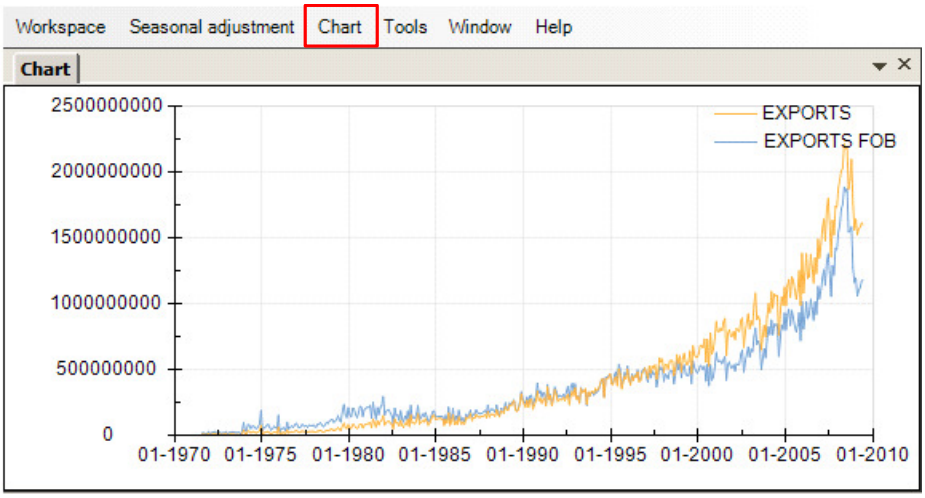


The group cannot be marked using **Ctrl** button from the keyboard. One can add the series to chart or grid by dragging and dropping them one by one.

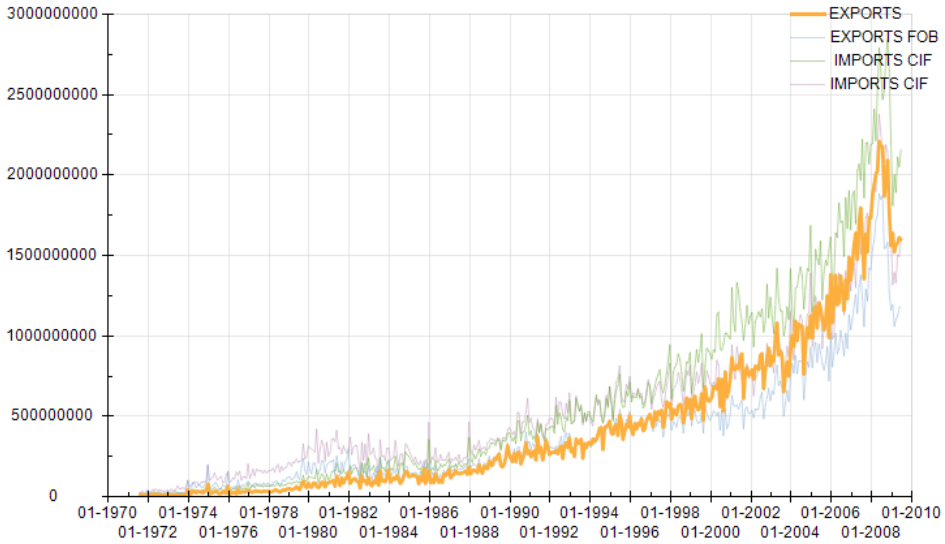
Different series, which appear in the results window (X12 or TramoSeats), can be dragged and dropped to any other window of the Tools menu. It is also possible to drag and drop the results in the item chosen from container.



When a container is active, its name is added to the menu toolbar.



The chart (or growth chart) is automatically rescaled after adding new series. Also new item *Chart* (or *Growth Chart*, respectively) is added to menu toolbar. Putting numerous time series into one chart could make it confusing. In this case the user can click on one series which is then displayed in bold.



The right-button menu offers many useful options. Its content depends on the type of container. For example, for the growth chart the following options are available:

Copy – copies raw series and allows to paste it e.g. into Excel. The function is active if the user clicks on the time series in the chart,

Copy growth data – copies m/m (or q/q) growth rates of the marked time series and allows to paste it e.g. into Excel. The function is active if the user clicks on the time series in the chart,

Remove – removes time series from the chart. The function is active if the user clicks on the time series in the chart,

Copy all – copies all raw time series and allows pasting it into e.g. Excel,

Copy all growth data – copies m/m (or q/q) growth rates of the time series and allows to paste it e.g. into Excel,

Remove all – removes all time series from the chart,

Paste – pastes time series previously marked,

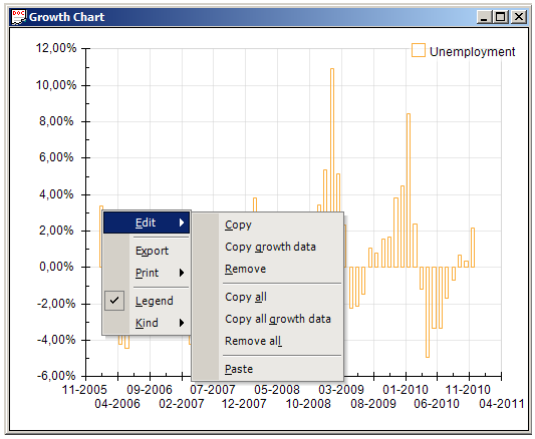
Export – settings for export the chart, the option for chart can be copy to clipboard and save to file is also available,

Print – allows printing the graph and setting the print preview and printing page setup options,

Legend – add/removes legend from the chart,

Kind – displays m/m or (q/q) and y/y growth rates for all time series in the chart (*previous period* and *previous year* options respectively),

Settings – allows to adjust the chart to the user's preferences (the user can change color scheme, change a line chart to the bar chart, show hide vertical and horizontal axis, show/hide legend, show/hide title, modify title, change to log scale).

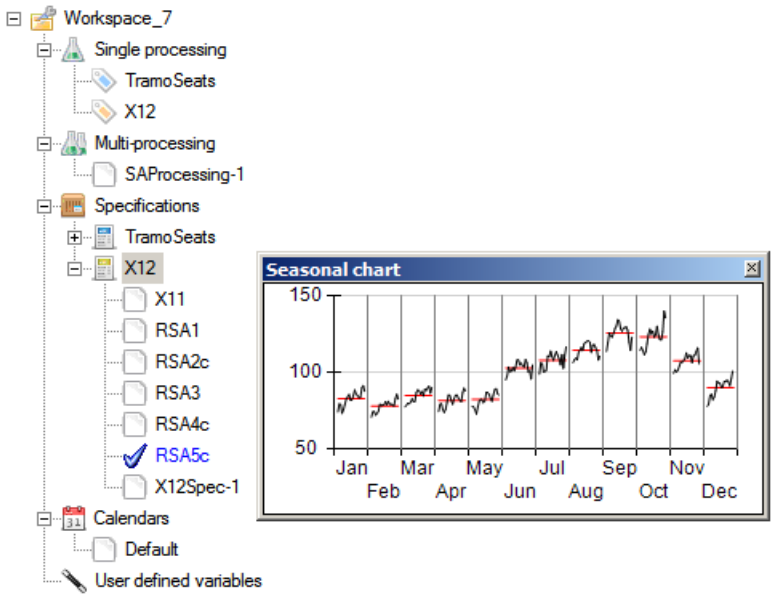


3.2.2. Tool window

The *Tool* window offers the following options: **TS Properties**, **Chart**, **Growth Chart**, **Seasonal Chart**, **Spectral Analysis and Differencing**. The first three of these have been described in previous sections. The remaining ones are characterised below.

3.2.2.1. Seasonal chart

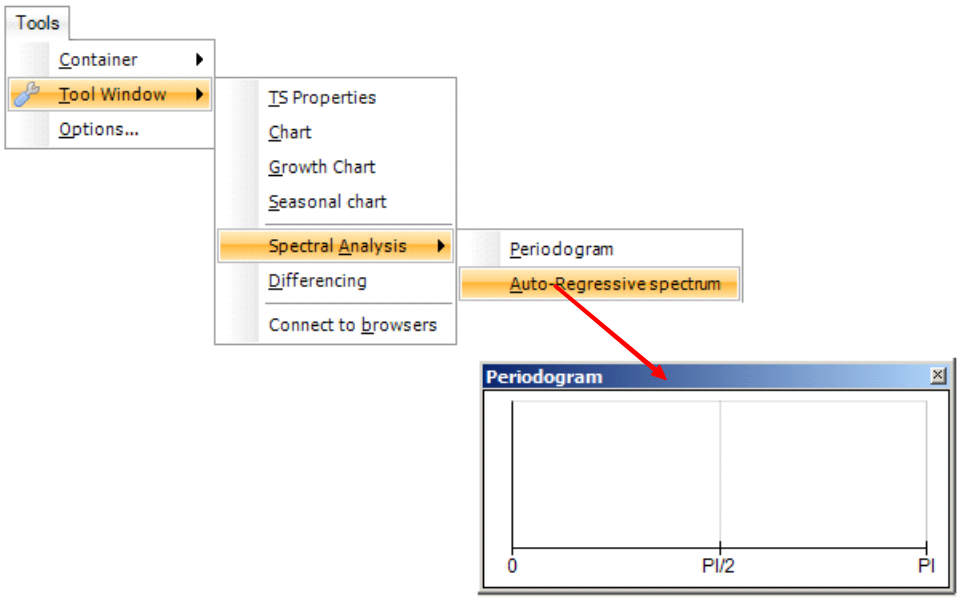
Seasonal charts present the final estimation of the seasonal-irregular component and final seasonal factors for each of the periods in a time series (months or quarters). To calculate them Demetra+ uses the active specification (the one which is marked in the *Workspace menu*).



The curves visible on the chart represent the final seasonal factors and the straight line represents the average for these values in each period. For more detail see 4.3.2.1.1.

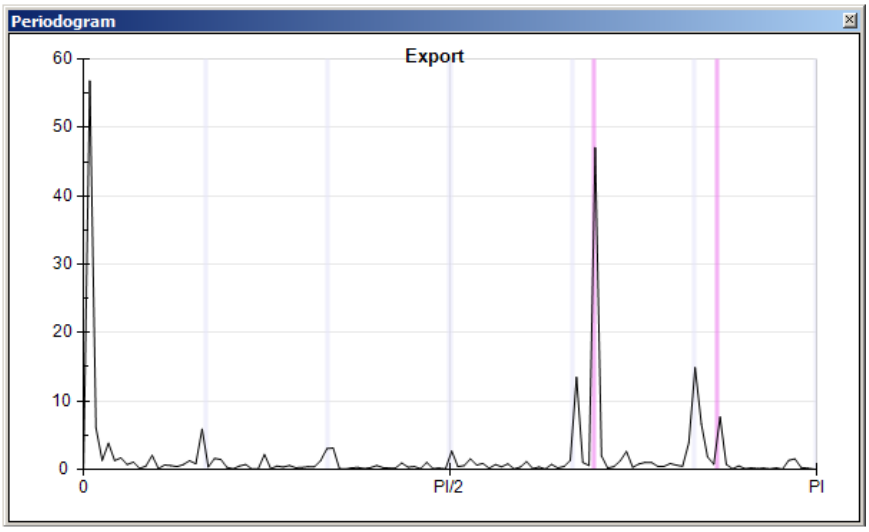
3.2.2.2. Spectral analysis

Demetra+ offers two spectral estimators – periodogram and autoregressive spectral estimator[7]. After choosing one of them from *Tools* menu the empty window is displayed.



To calculate periodogram drag and drop a raw time series into the displayed window. A methodological note about spectral analysis is available at the end of the Manual.

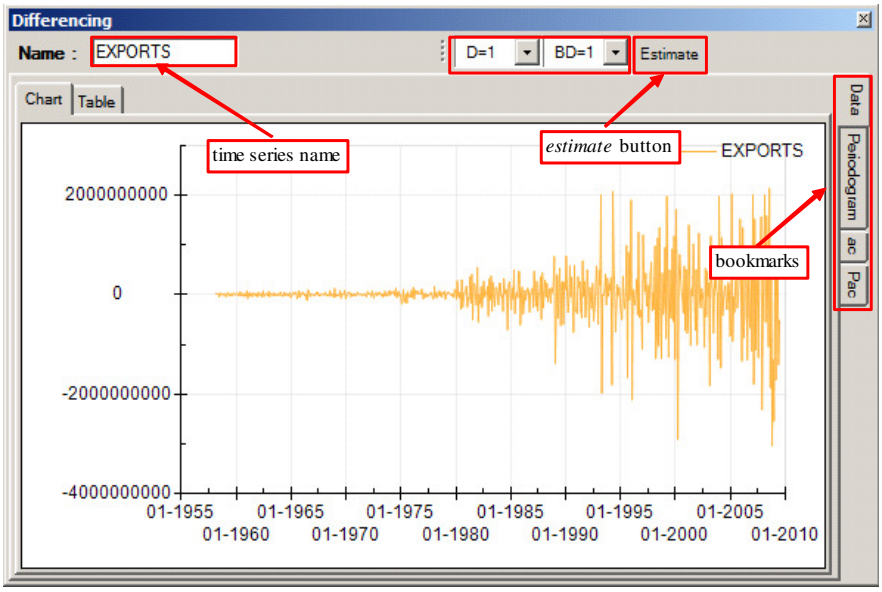
7 For more information see the Annex, section 7.



The auto-regressive spectrum can be generated in the same way.

3.2.2.3. Differencing

Differencing window gives the access not only to the data (presented in chart and table) and spectral graphs but also to ACF and PACF functions for selected time series. In order to obtain the output, the time series from the list should be dragged and dropped precisely into *Name* box.



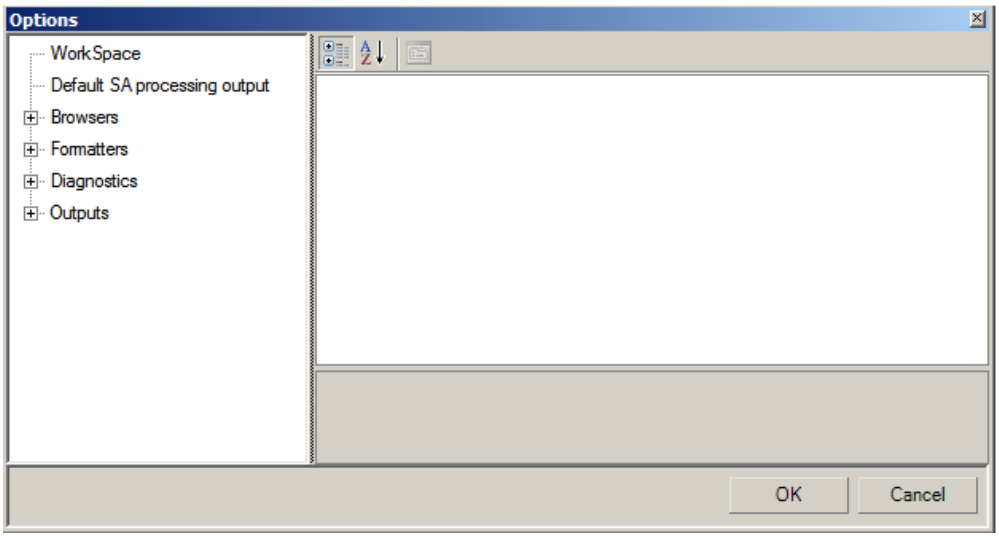
Using the bookmarks on the right the user could switch to other functions like periodogram and auto-regressive spectrum, autocorrelation function and partial autocorrelation.

Once the user changes the differencing orders (D – regular differencing order, BD – seasonal differencing order) or changes the time series the results are updated automatically. The user can identify D and BD parameters that generate stationary time series using *Estimate* button.

In right-button menu standard options (like: **Copy**, **Export**, **Print**) are available.

3.2.2.4. Options

The window contains the default options used by the Demetra+.



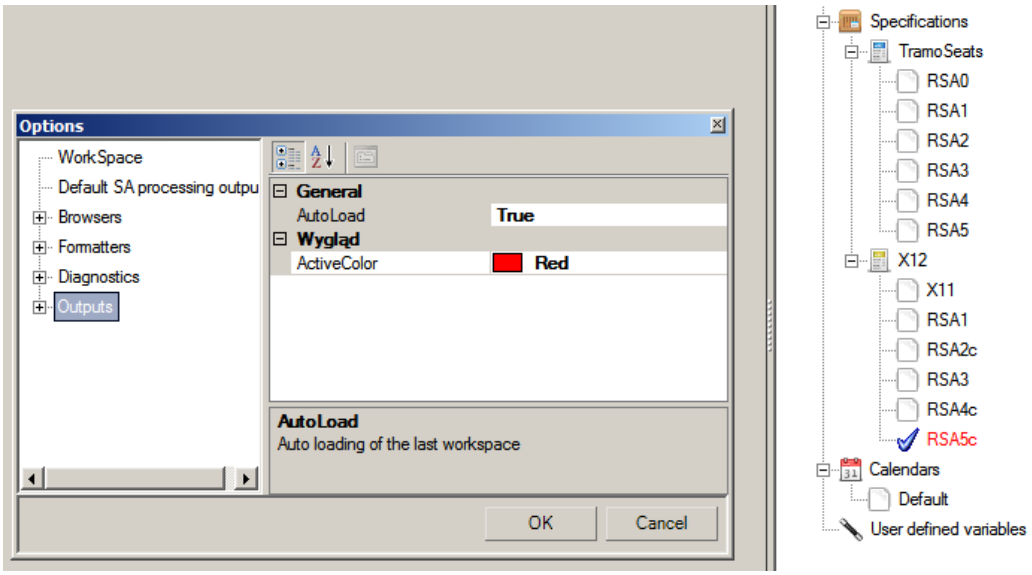
The initial settings can be modified by the user. The menu includes:

- setting for workspace,
- default processing output,
- settings for the browsers,
- formatters for txt and xml files,
- settings for presentation the diagnostic where the user can change the critical values and other parameters for diagnostic tests,
- outputs, where the folder that will contain the results is specified.

Those functions are discussed below.

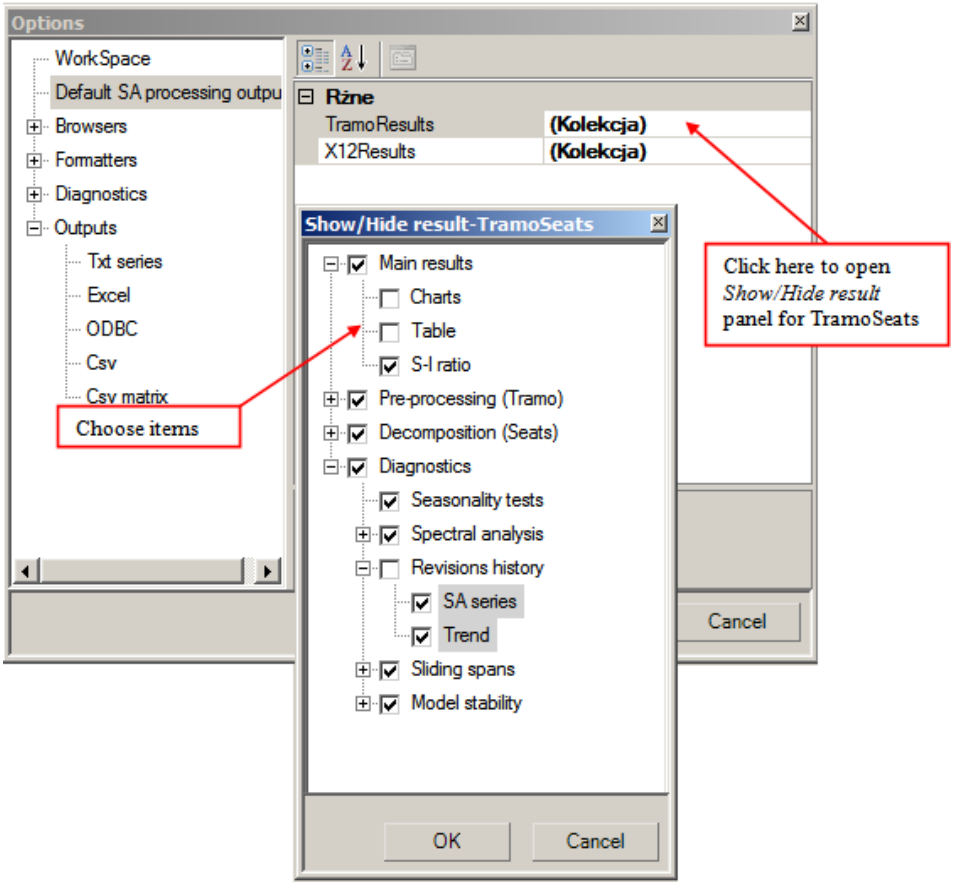
WorkSpace

This node enables the user to switch on/off auto loading of the last workspace and to choose the colour for the active item in the *Workspace* panel. By default the active item is blue. Here the change to red was made.



Default SA processing output

The user can decide which parts of the results will be presented after seasonal adjustment (SA) processing. To do it, for each SA method the user can show or hide the items from the list of results. By default all items are displayed after SA processing. The picture below presents that two diagnostics will not be visible in the SA results from TramoSeats.

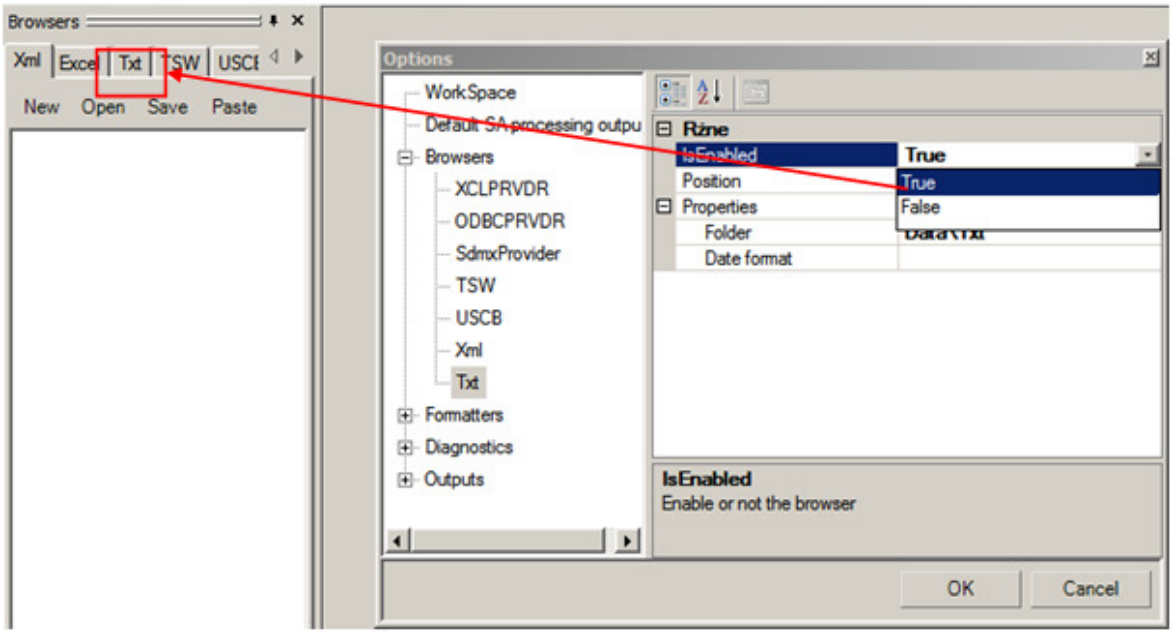


Browsers

Demetra+ can load data from the following data sources:

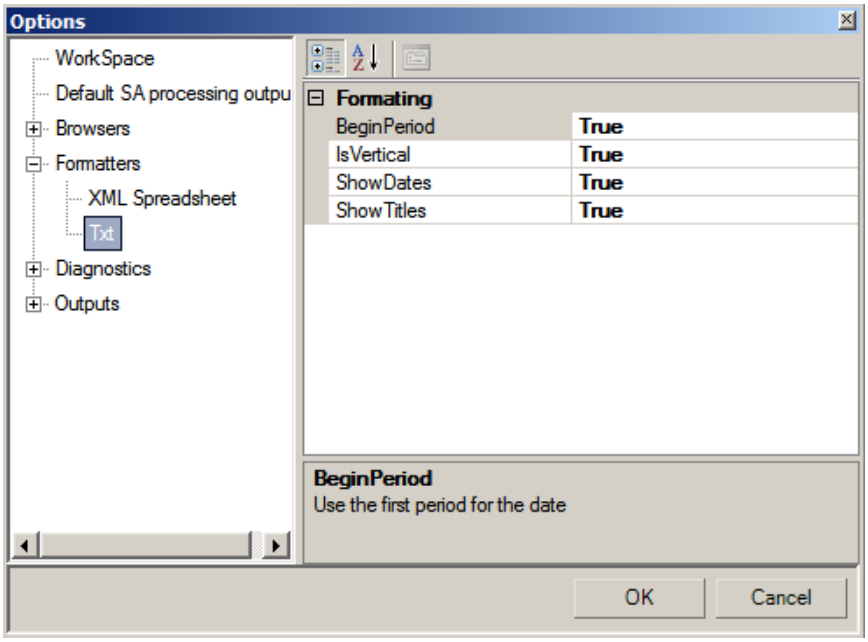
- Excel (XCLPRVDR),
- ODBC (Open Database Connectivity - a standard software interface for accessing database management systems),
- SDMX (Statistical Data and Metadata eXchange - a ISO standard for exchanging and sharing statistical data and metadata among organizations),
- TSW (denotes "TRAMO-SEATS for Windows" – the seasonal adjustment software developed by the Bank of Spain),
- USCB (denotes "X-12-Arima" – the seasonal adjustment software maintained by the U. S. Census Bureau),
- Xml (Extensible Markup Language designed to describe data),
- Txt.

With default settings the xml, Excel, TSW and USCB sources are available. The user can add/remove data sources with option *IsEnabled.* The order of the data sources visible in the *Browsers* window can be arranged with *Position* function (the source with the smallest position value is displayed on the left in the *Browsers* panel).



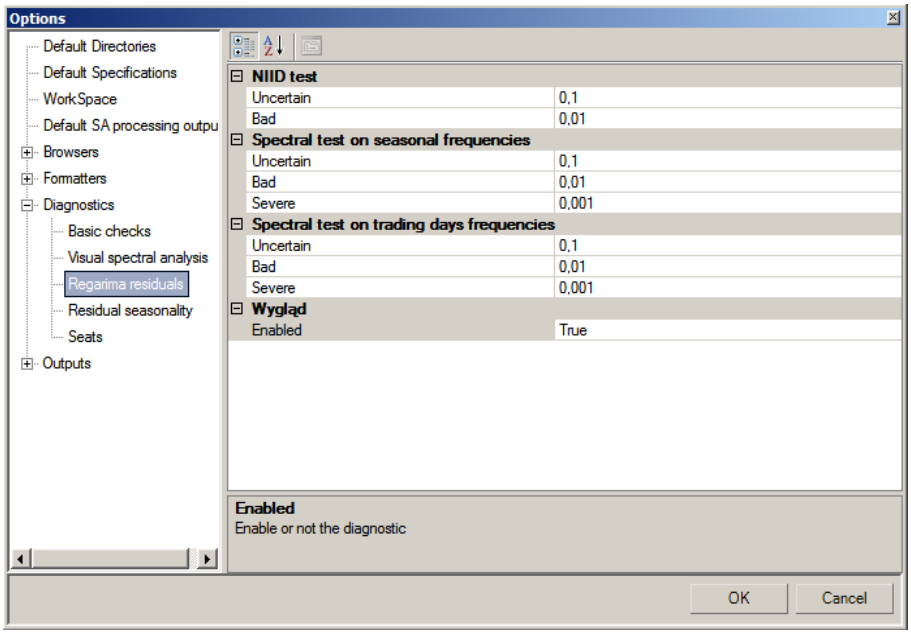
Formatters

For XML and TXT data sources Demetra+ offers formatting options like switching between vertical and horizontal presentation of the data, showing dates and titles of the series and using or not the first period for the date.



Diagnostic

This part includes information about the chosen significance level used by Demetra+ for an evaluation of the performed seasonal adjustment. The default settings for the tests, displayed in this section, can be changed by the user.



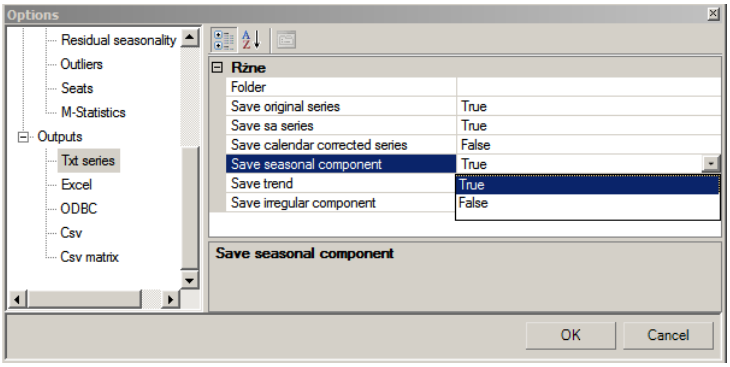
For the spectral analysis the following settings are also included: threshold for identification of peaks, number of years (at the end of the series) considered in the spectral analysis, checking if the spectral peak appears on both SA series and irregular component.

Outputs

This section enables to specify which output's items will be saved and folder in which Demetra+ saves the results. It is possible to save the results in the following formats: txt, xls, csv or send them to the database by ODBC.

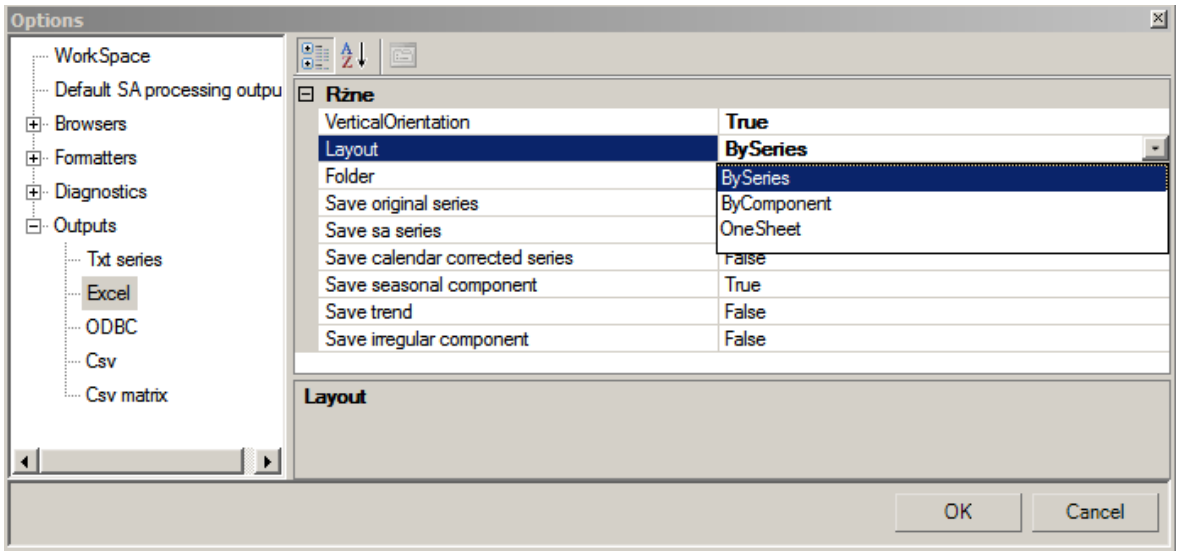
TXT

With the txt format the user can define the folder that will contain the results and the components that will be saved.

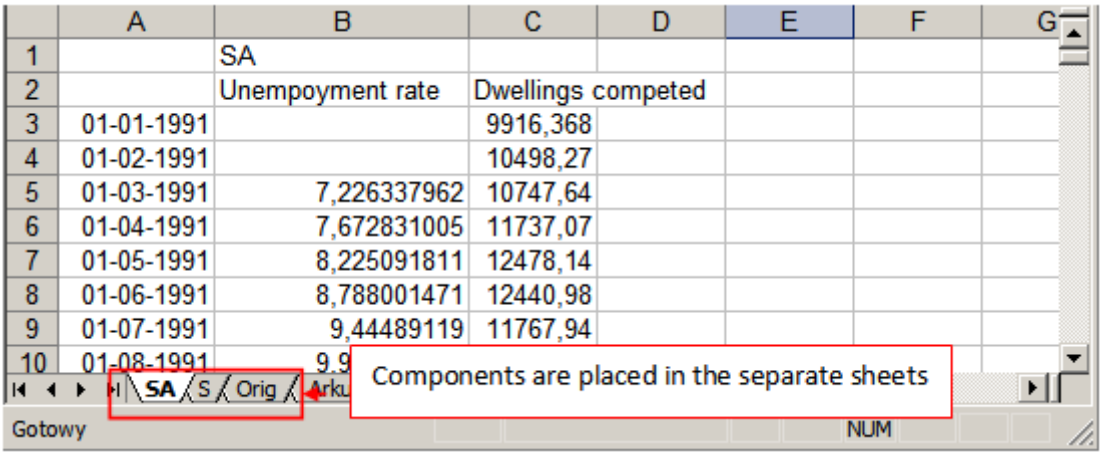


XLS

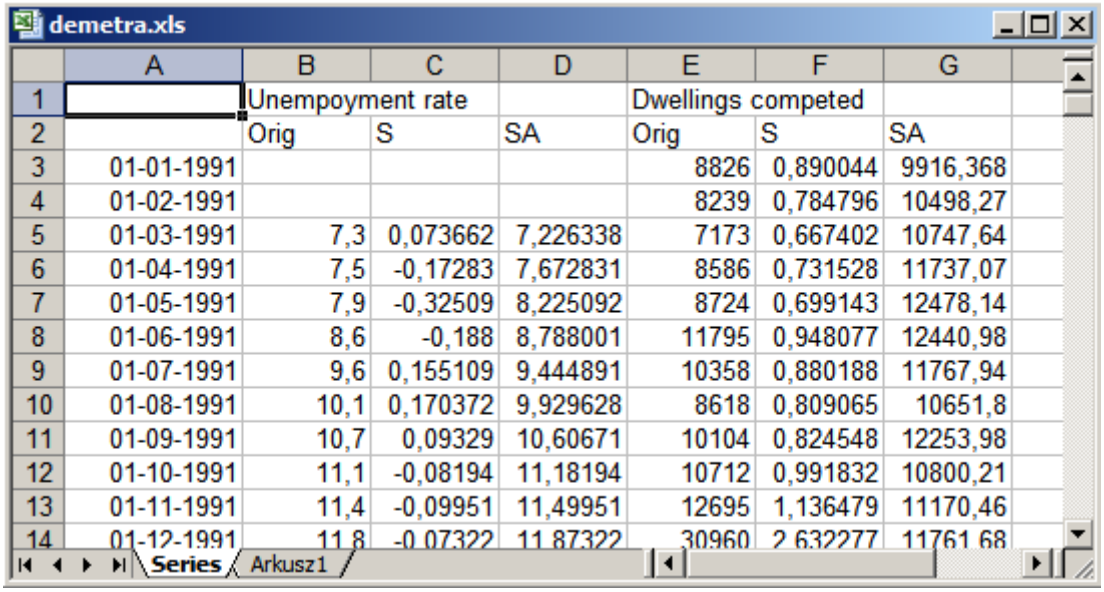
In addition to the options available for txt format, using xls format the user can specify the layout.



If the user will set the option layout to *ByCompenent* the output will be generated in the following way:

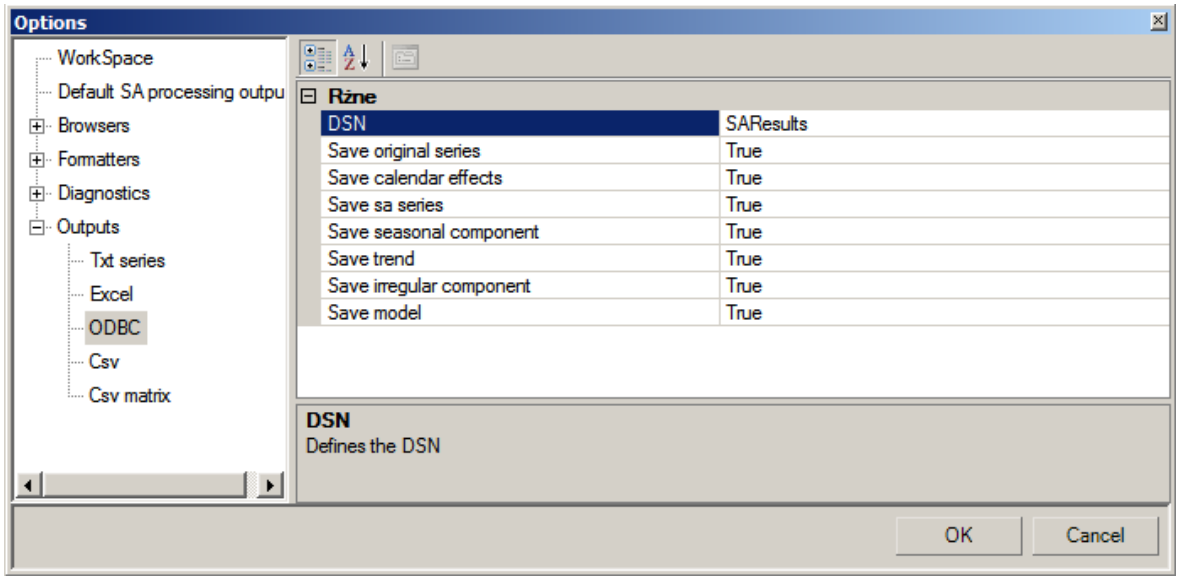


The option *OneSheet* will produce the following xls file:



ODBC

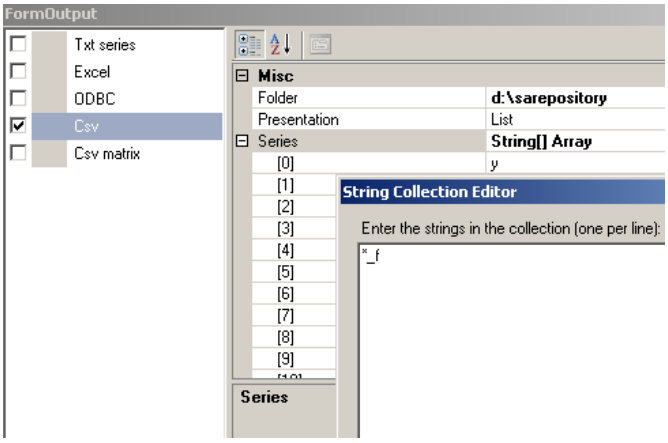
After choosing odbc option, the user should specify database source name (DSN). Needless to say, this database should be previously created. The user defines the components that will be sent to the database.



CSV

By using the csv format it is possible to save for multi-processing documents a large number of time series generated by the models. For all the series of the processing each file contains a specific output (for instance, the calendar effects of all the series will be put together in one file). The different files will contain one item (row or column) for every series in the processing, even if that item is empty. The software can generate different layouts: the series can be presented in the form of horizontal or vertical tables (each row/column corresponding to the same period) or in the more compact form of horizontal lists of data.

The series must be introduced in the *String Collection Editor* (one code by row). The user can also use wildcards, in the usual way, to identify the series.



For example the following collection:

***_f**

D*

y?

will generate all the forecasts, all the "D-tables" of X11 and the series "yc", "yl".

The different files will be stored as follows:

<folder>\[<workspace name>]\<processing name>_<code>.csv

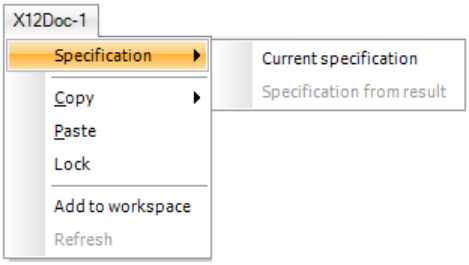
where:

- <**folder**> is specified by the user or the temporary folder if unspecified,
- <**workspace name**> is the workspace name (can be omitted),
- <**processing name**> is the name of the multi-processing,
- <**code**> has been defined above.

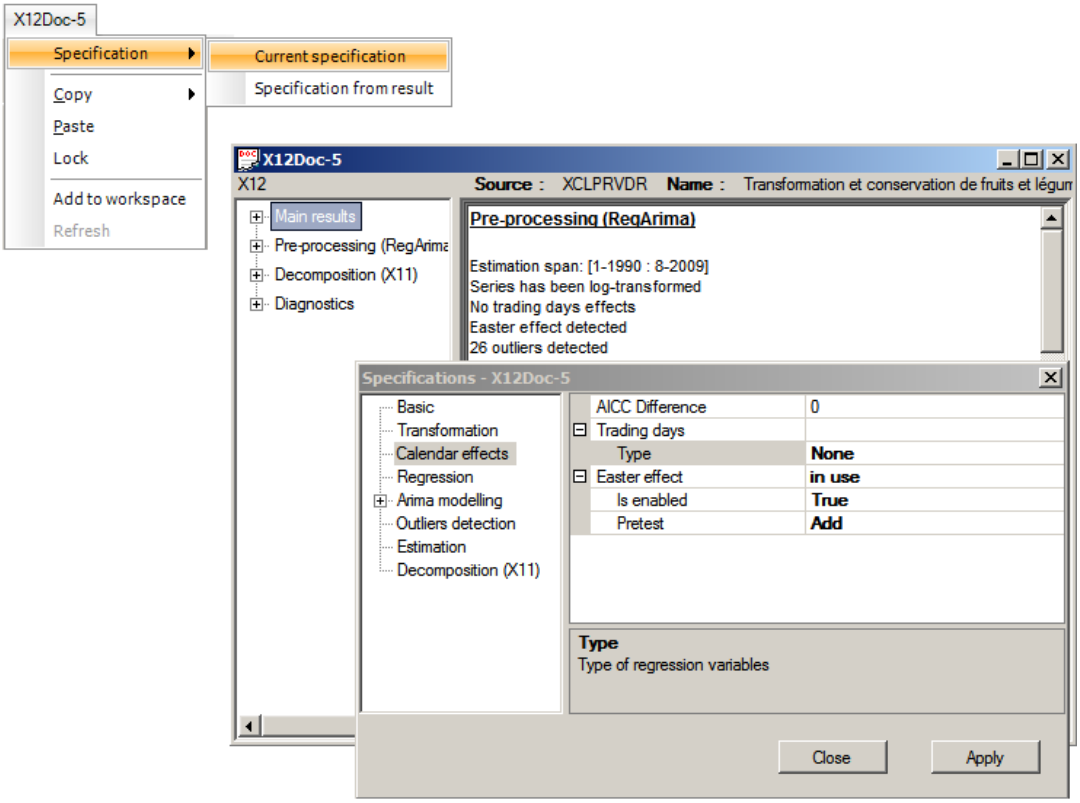
It should be noted that for multi-processing that don't belong to a workspace, the **[<workspace name>]\<processing name>** sequence is replaced by "**demetra**".

3.3. X12 Doc

This item is visible in the application's menu when X12 seasonal adjustment has been previously executed and after that it has been activated by the user.



The option *Current specification* opens specification that is currently displayed in the central application panel. The user can modify the specification and validate changes using the *Apply* button. Demetra+ re-estimates the complete seasonal adjustment model automatically, so the results are updated immediately.



Detailed description of the X12 specifications is presented in Chapter 4.1.

The option *Specification from results* works in the similar way as the *Current specification*. It is active when the processing has been executed.

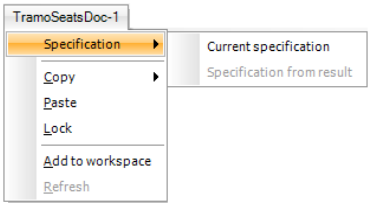
Add to workspace – adds the single-processing to the workspace's tree,

Copy – copies item chosen by the user (Results, Processing, Current specification, Specification from results),

Paste – pastes the item previously copied.

3.4. TramoSeats Doc

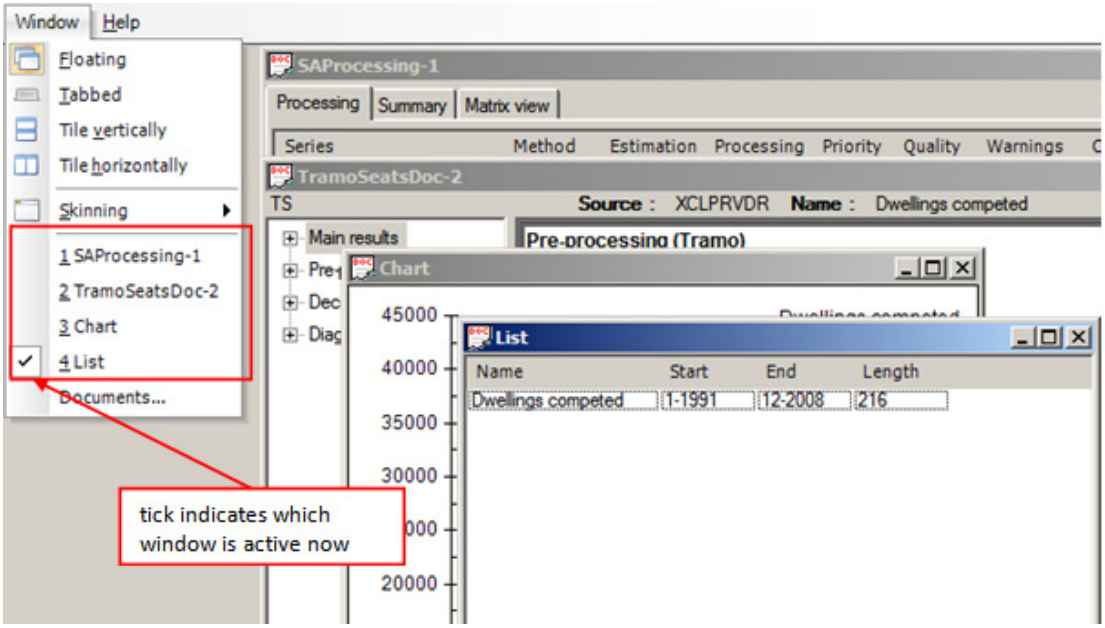
This item is added to the application's menu when seasonal adjustment using TramoSeats method has been previously executed and after that it has been activated by the user. This item offers the similar options set as the X12Doc. Detailed description of the TramoSeats specifications is presented in Chapter 4.2.



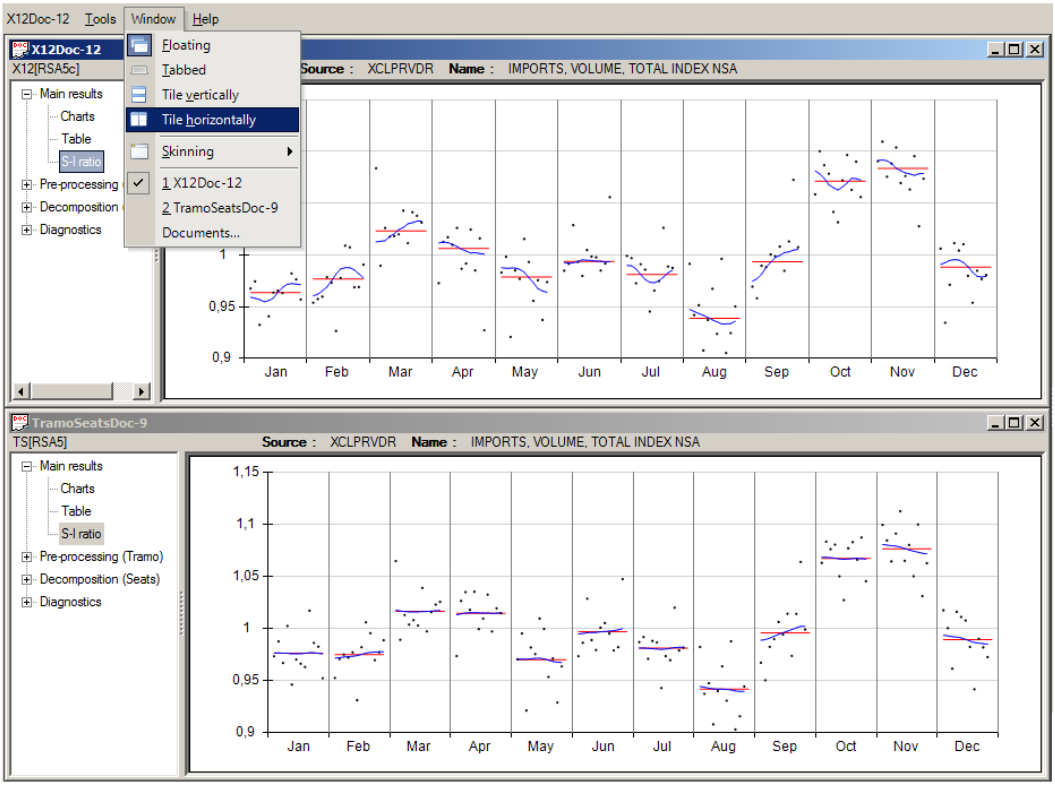
3.5. Window menu

Window menu offers the following functions:

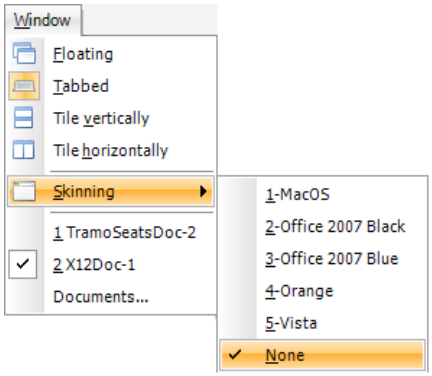
- **Floating** – show additional information while keeping the user in the same window,
- **Tabbed** – arranges all windows in central zone as tabs,
- **Tile vertically** – arranges all windows in central zone vertically,
- **Tile horizontally** – arranges all windows in central zone vertically,
- **Skinning** – allows to custom graphical appearance of Demetra+,
- **Documents**,
- List of windows' names currently displayed in the central panel. This list is dynamically updated when the user opens/close some windows. On the example below four items are available. The one which is active is marked.



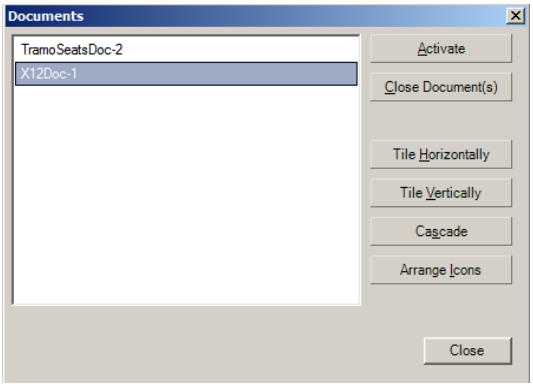
As an example, the following chart presents the comparison of the results for **Tile** horizontally option.



Demetra+ offers six different skinning:



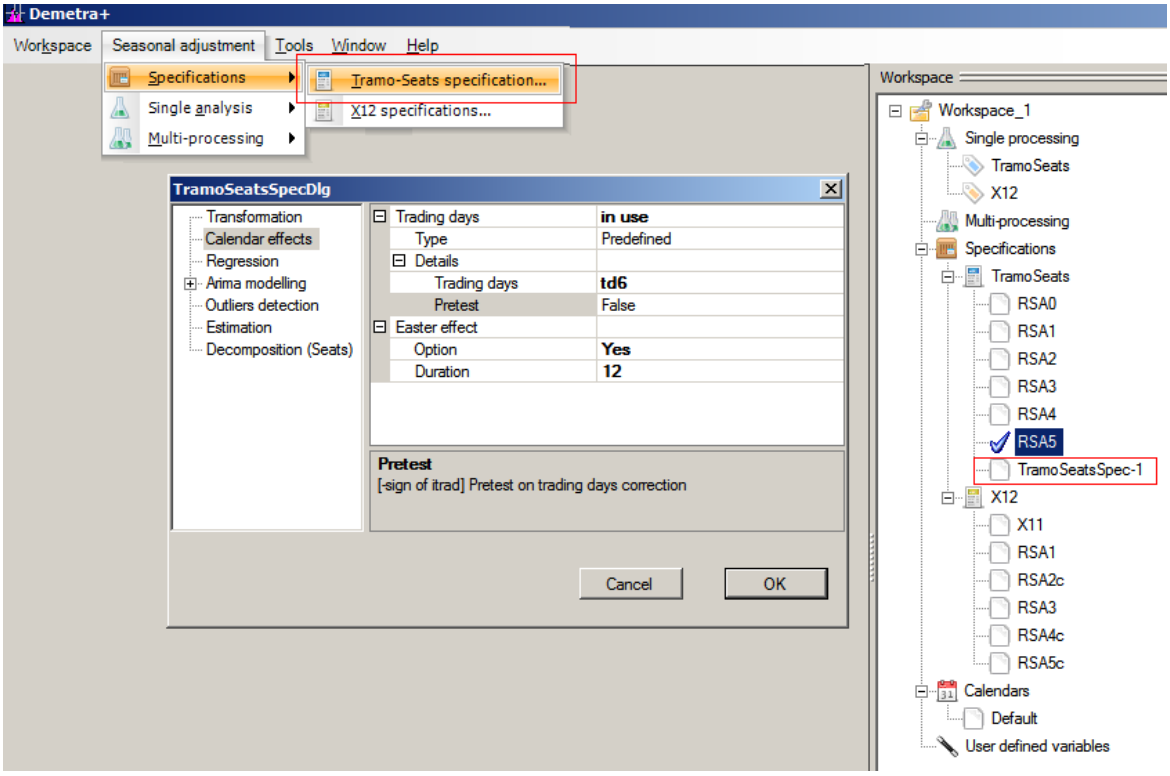
Documents option offers some additional options helpful for organising windows. The left panel contains the list of all windows currently displayed in central panel of Demetra+. On the right activate/close buttons and a presentation styles are available.



4. Seasonal adjustment

Demetra+ provides two methods of seasonal adjustment: TramoSeats and X12. For both methods a list of pre-defined specifications is available (using the naming conventions of TramoSeats). This list contains the most commonly used specification for seasonal adjustment. Pre-defined specifications correspond to the terminology used in TramoSeats[8] and are described in the Annex (section 3A). The default specifications appear in the Workspace tree. The users are strongly recommended to start their analysis - as explained below - with one of those specifications (usually RSA4c or RSA5c for X12 and RSA4 or RSA5 for TramoSeats) and to change afterwards some of the options, if need be.

For more advanced users Demetra+ offers an opportunity to create the new specifications for seasonal adjustment and to add them to the list. This could be done by choosing the *Seasonal adjustment* item from the main menu and clicking the *Specifications* sub-menu. In the next step the user should make a choice between **TramoSeats specification…** and **X12 specification…**. After the user has chosen all the suitable options in the Specifications dialog box, the new specification is automatically sent to the corresponding node of the Workspace. The new specification will be saved with the workspace, for future use. It can be later used in the same way as any predefined specification.



8 Description from CAPORELLO, G., and MARAVALL, A. (2004).

The next two sections contain valuable information about the specifications. The description of X12 specifications is presented in 4.2 and a description of TramoSeats specifications is presented in 4.3.

Demetra+ is able to perform seasonal adjustment for one single time series as well as for the whole set of time series. The first option is called single processing (see 4.1) and is used for detailed analysis of the time series. The second option, called multi-processing (see 4.2), is a convenient tool for mass production of seasonally adjusted time series.

4.1. X12 specifications

The X12 specification is - to a very large extent - organized following the different individual specs of the original program (taking into account that peripheral specifications or specifications related to diagnostics are handled in a different way).

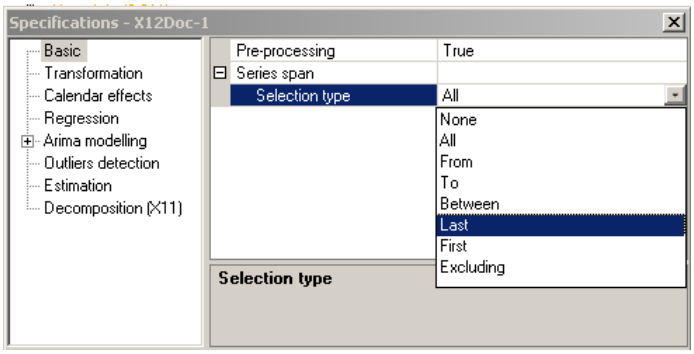
The different parts of the specification are presented in the order in which they are displayed in the graphical interface of Demetra+. Details on the links between each item and its corresponding X12 spec/argument are provided in the following paragraphs. For an exact description of the different parameters, the user should refer to the documentation of the original X12 program.

4.1.1. General description

Item	X12 spec file	Meaning
Basic	*series*	General options for the processing
Transformation	*transform*	Transformation of the original series
Calendar effects	*regression*	Specification of the part of the regression related to calendar
Regression	*regression*	Specification of the part of the regression which is not specifically related to calendar
Automatic modeling	*automdl*	Automatic model identification
Arima	*arima*	Arima modeling
Outliers detection	*outlier*	Automatic outliers detection
Estimation	*estimate*	Options on the estimation procedure of the RegArima model
Decomposition (X11)	*x11 [forecast]*	X11 decomposition

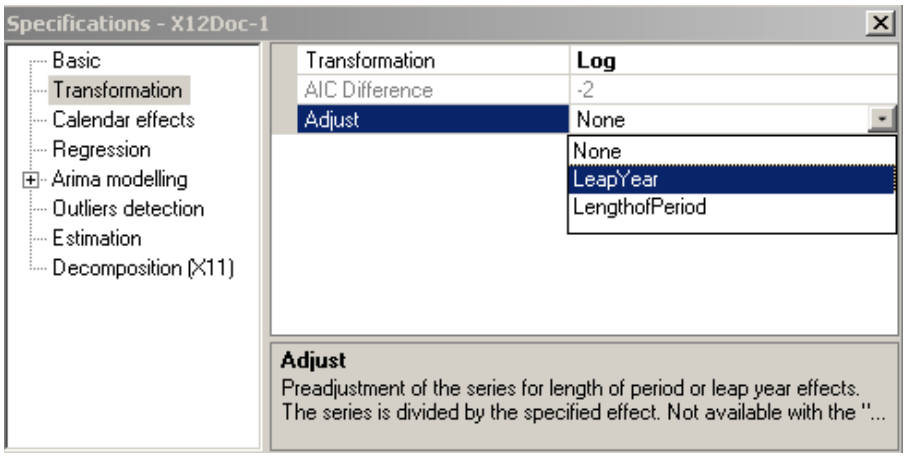
4.1.2. Basic

Item	X12		Comments
	Individual spec	Argument	
Pre-processing			Enable/Disable the other individuals specs, except X11
Series span -> selection type	*series*	*span*	Span (data interval) of the available time series used for the processing. The span can be computed dynamically on the series (for instance "Last 90 obs")



4.1.3. Transformation

Item	X12		Comments
	Individual spec	Argument	
Transformation	transform	function	Demetra+ accepts the following options: • None – data are not transformed, • Log – logarithms from original values are taken, • Auto – Demetra+ tests which option: "None" or "Log" is better for the particular time series
AIC Difference	transform	aicdiff	Disabled when the transformation is not set to "Auto"
Adjust	transform	adjust	Acceptable values: • LeapYear – include a contrast variable for leap-year, • LengthofPeriod – include length-of-month (or length-of-quarter) as a regression variable



4.1.4. Calendar effects

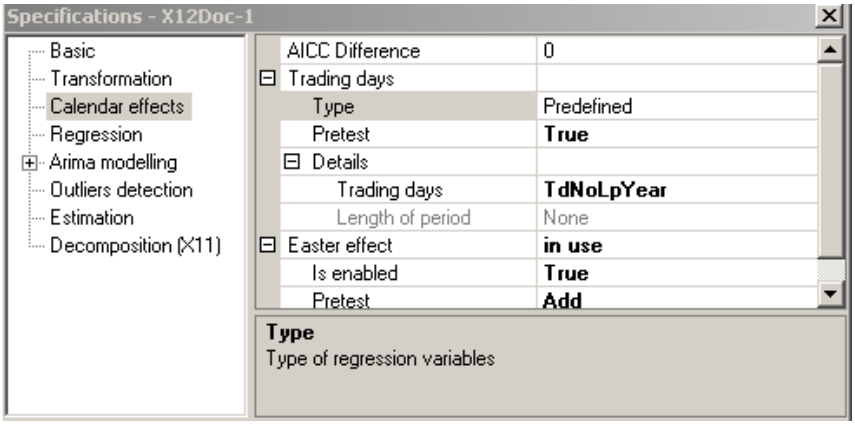
Item	X12		Comments
	Individual spec	**Argument**	
AICC Difference	*regression*	*aicdiff*	Demetra+ only considers pre-tests on regression variables related to calendar effects (trading days or moving holidays)
Trading days -> Type	-	-	The user can choose between four ways of trading days estimation: • None, • Predefined, • Calendar, • UserDefined. "None" means that Calendar effects will not be included in the regression; "Predefined" means that default Calendar will be used; "Calendar" option corresponds to the pre-defined trading days variables, modified to take into account specific holidays. It means that after choosing this option the user should specify the type of trading days effect (td1,td2, td6 or td7) and chose the calendar which will be used for holidays' estimation; "UserDefined" is used when the user wants to specify in a free way his own trading day variables. With this option the calendar effect is captured only by regression variables chosen by user from the previously created User defined variables.
Trading days -> Pretest	*regression*	*aictest*	Pretest the significance of the trading days regression variables using AICC statistics
Trading days-> Details -> Trading days	*regression*	*variables*	Acceptable values: • Td – include the six day-of-the week variables and a leap year effect,

Item	X12		Comments
	Individual spec	**Argument**	
(option is available if Trading days ="Predefined" or "Calendar type")			• td1Coef – include the weekday-weekend contrast variable and a leap year effect, • tdNoLpYear – include the six day-of-the week variables, • td1NoLpYear – include the weekday-weekend contrast variable. Some options can be disabled when the adjust option is used in the "transformation" specification
Trading days-> Details -> Length of period (option is available if Trading days ="Predefined" or "Calendar type")	*regression*	*variables*	Acceptable values: • LeapYear – include a contrast variable for leap-year, • LengthofPeriod – include length-of-month (or length-of-quarter) as a regression variable. Can be disabled when the adjust option is used in the "transformation" specification or with some trading days options.
Trading days-> Details -> Holidays (option is available if Trading days = "Calendar type")	-	-	When the user chooses the "calendar" type for the trading days, one must specify the corresponding holidays. It should be noted that such a holiday must have been previously defined (see 3.1.1).
Trading days-> Details -> Items (option is available if Trading days = "UserDefined")	*regression*	*user, usertype= (...td...)*	When the user chooses the "userdefined" type for the trading days, one must specify the corresponding variables. It should be noted that such variables must have been previously defined (see 3.1.2).
Easter -> IsEnabled	*regression*	*variables and/or aictest*	The option enables the user to estimate the Easter effect in three different ways. The user can choose between tree pre-test options: • Add, • Remove, • None. Trading days and holiday adjustments may be obtained from RegArima part or from irregular regression models. When the user chooses the "Add", "easter" is only added in the "variables" part of the

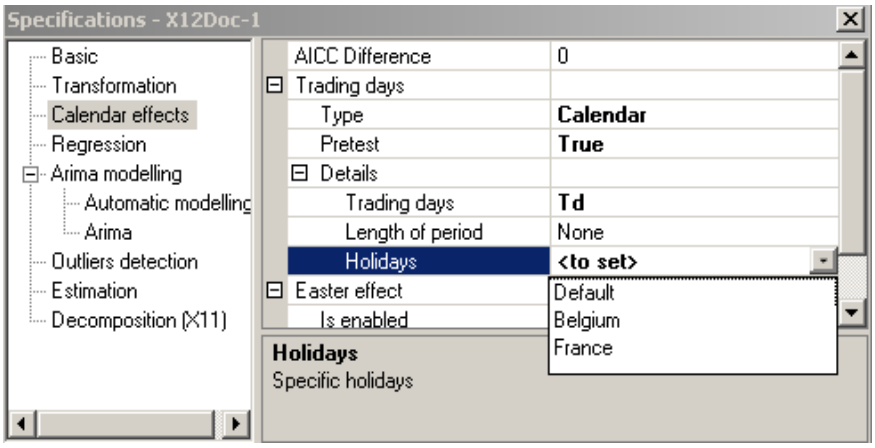
Item	X12		Comments
	Individual spec	Argument	
			regression spec. An automatic identification of the Easter length (between 1, 8 and 15 days) is executed. When one chooses the "Remove", "easter" is added in the "variables" and in the "aictest" parts of the regression spec. The specified length of the Easter effect is used. When one chooses the "None", "easter" is only added in the "variables" of the regression spec. The length of the Easter effect specified by the user is used. The length of the Easter effect can range from 1 to 20 days. It should be noted that the "Length" option is hidden when the "Add" pre-test option is active.
Pretest	*regression*	*aictest*	Pretest the significance of the Easter regression variables using AICC statistics
Length	*regression*	*easter[w]*	Duration of the Easter effect (w - length in days of the Easter effect). The parameter is active if the *aictest*=None

The current version of Demetra+ doesn't allow the use of stock trading days. Pre-defined calendar day for the handling of *Labor Day* and of *Thanksgiving* are not available (see 3.1.1. for list of pre-defined holidays). Nevertheless the user is allowed to create any fix day regression variable.

Example: predefined trading days

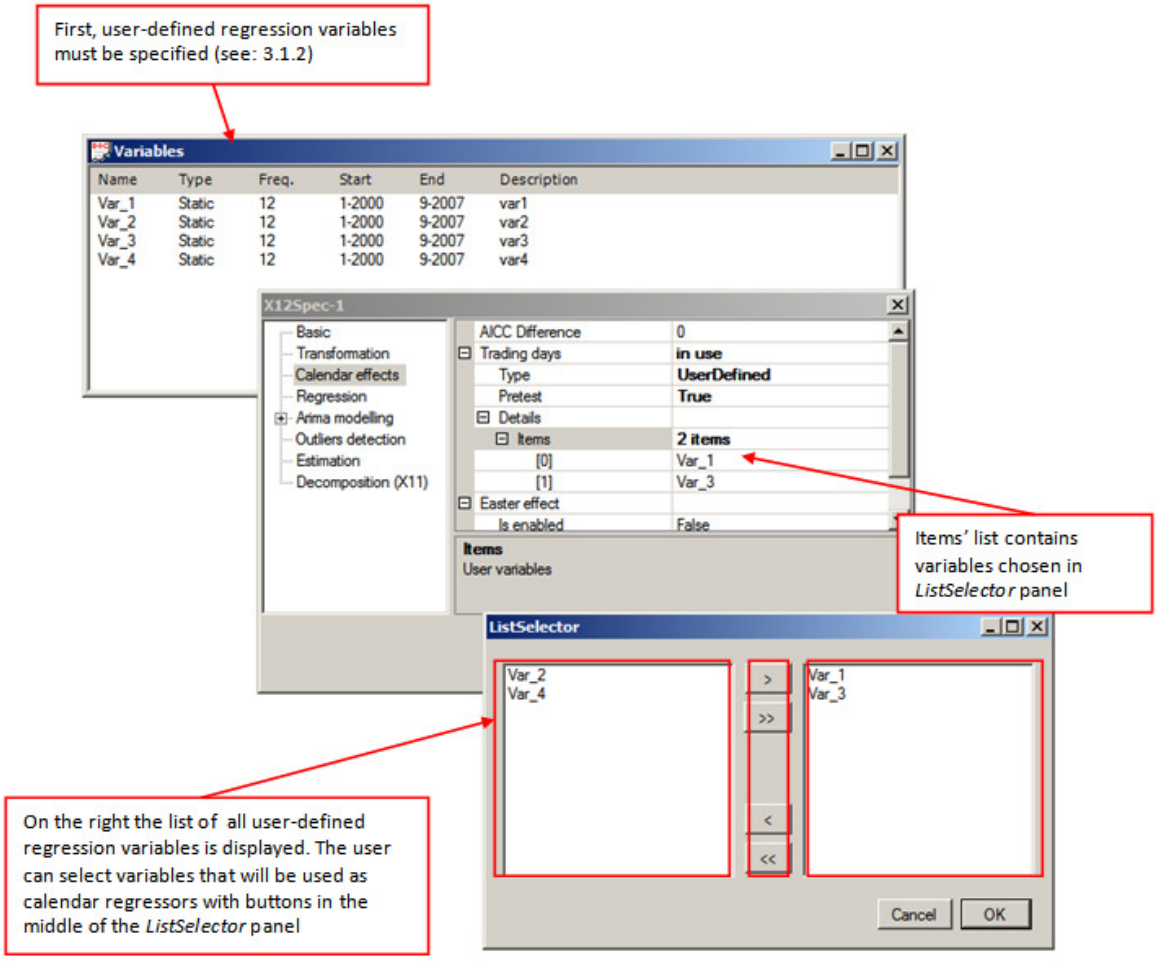


Example: calendar trading days

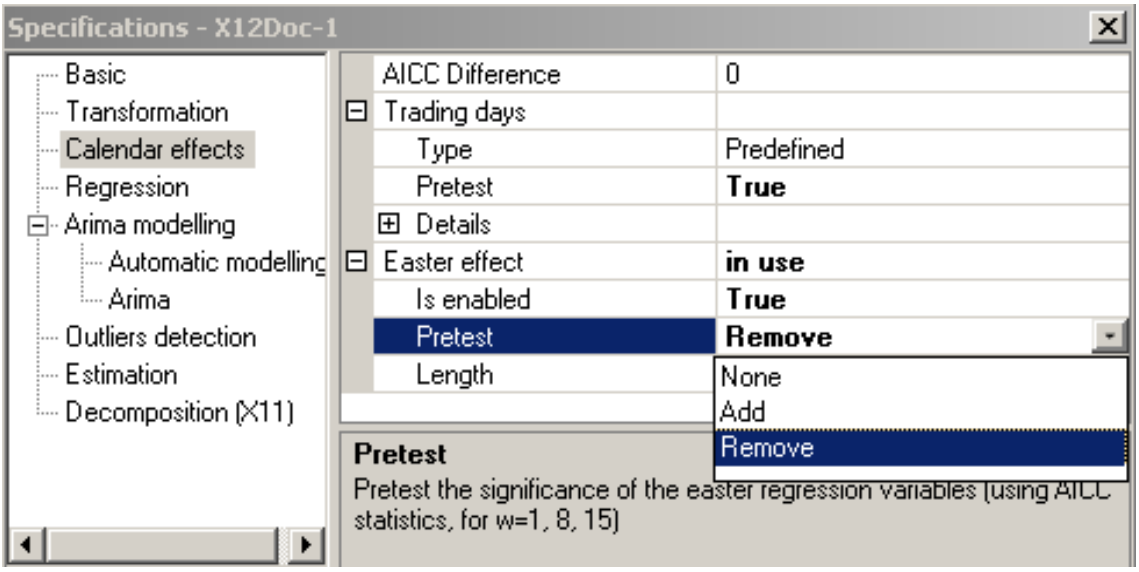


Example: user-defined trading days

This option is available if the user has created user defined variables (see 3.1.2).



Example: Easter effect



4.1.5. Regression

Item	X12		Comments
	Individual spec	Argument	
Pre-specified outliers	regression	variables	User-defined outliers are used if prior knowledge suggest that such effects exist at known time points[9]: • Additive Outlier (AO) – additive, point outlier which occurred in a given date t_0 . It is modeled by variable $AO_t^{t_0} = \begin{cases} 1 \; for \; t = t_0 \\ 0 \; for \; t \neq t_0 \end{cases}$, • Level shift (LS) – variable for a constant level shift beginning on the given date t_0 . It is modeled by regression variable $LS_t^{t_0} = \begin{cases} -1 \; for \; t < t_0 \\ 0 \; for \; t \geq t_0 \end{cases}$, • Temporary change[10] (TC) – variable for a temporary level change beginning on the given date t_0 . It is

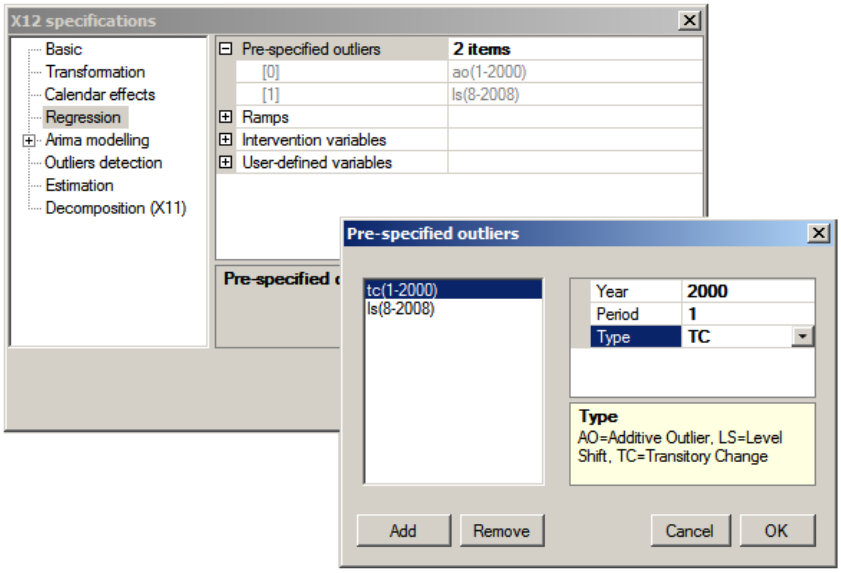
9 Definitions from: 'X12-ARIMA Reference Manual', (2007).
10 In TramoSeats method this type of outlier is sometimes called by transitory change.

Item	X12		Comments
	Individual spec	Argument	
			modeled by regression variable $TC_t^{t_0} = \begin{cases} 0 \ for \ t < t_0 \\ \alpha^{t-t_0} \ for \ t \geq t_0 \end{cases}$, where α is a rate of decay back to the previous level $(0 < \alpha < 1)$. Seasonal outliers are not supported. Pre-specified outliers are simple forms of intervention variables.
Ramps	regression	variables	Ramp effect means a linear increase or decrease in the level of the series over a specified time interval t_0 to t_1. It is modeled by regression variable $RP_t^{(t_0,t_1)} = \begin{cases} -1 \ for \ t \leq t_0 \\ (t-t_0)/(t_1-t_0)-1 \ for \ t_0 \leq t < t_1 \\ 0 \ for \ t \geq t_1 \end{cases}$. All dates of the ramps must occur within the time series. Ramps can overlap other ramps, additive and level shifts outliers.
Intervention variables	regression	variables	No corresponding X12 arguments. The intervention variables are defined as in Tramo. Following the definition, these effects are special events known a-priori (strikes, devaluations, political evens, and so on). Intervention variables are modeled as any possible sequence of ones and zeros, on which some operators may be applied. The most frequently used operators are: • Dummy variables, • Any possible sequence of ones and zeros, • $\frac{1}{(1-\delta B)} \ (0 < \delta \leq 1)$, • $\frac{1}{(1-\delta_s B^s)} \ (0 < \delta_s \leq 1)$ • $\frac{1}{(1-B)(1-B^s)}$ [11]. These operations enable to generate not only AO, Ls, TC and RP outliers but also sophisticated intervention variables that are well-adjusted to the particular case.

11 See BOX, G. E. P. and TIAO, G. C. (1975).

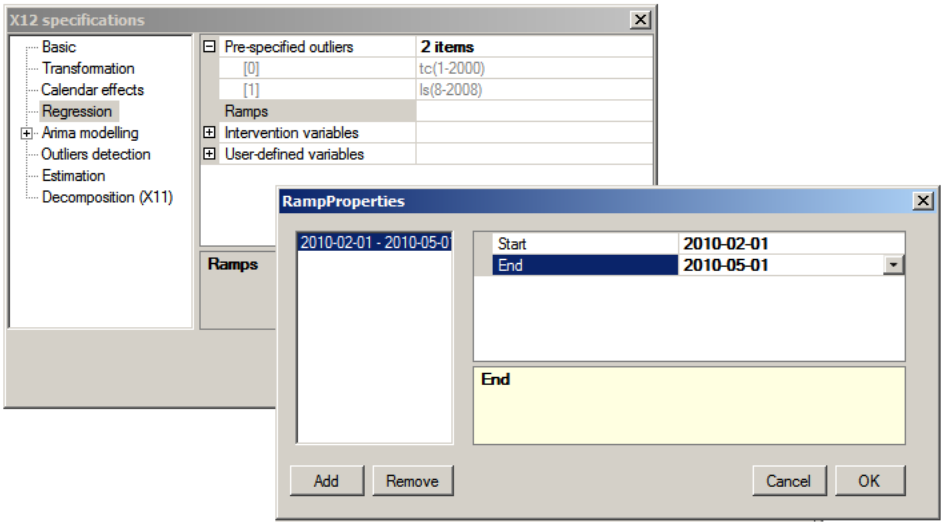
Item	X12		Comments
	Individual spec	**Argument**	
User-defined variables	regression	user, usertype	The user-defined variables effect can be assigned to the trend, irregular, holiday or can exist as an additional component (option "Undefined". For practical considerations, seasonal effects are currently not supported. The user can specify the structure of the lags[12]. When regression variable *Var* is introduced a with *first lag* $= l_a$ and *last lag* $= l_b$, Demetra+ estimates the following regression model for this variable: $Var_t = \beta_a x(t-l_a) + ... + \beta_b x(t-l_b)$ To estimate $Var_t = \beta_1 x(t-l_1)$ The user should put *first lag* = *last lag* = 1. If *first lag* = 0 and *last lag* = 12 it means that, in addition to instantaneous effect, the effect of variable *Var* is spread over one year.

Example: Pre-specified outliers

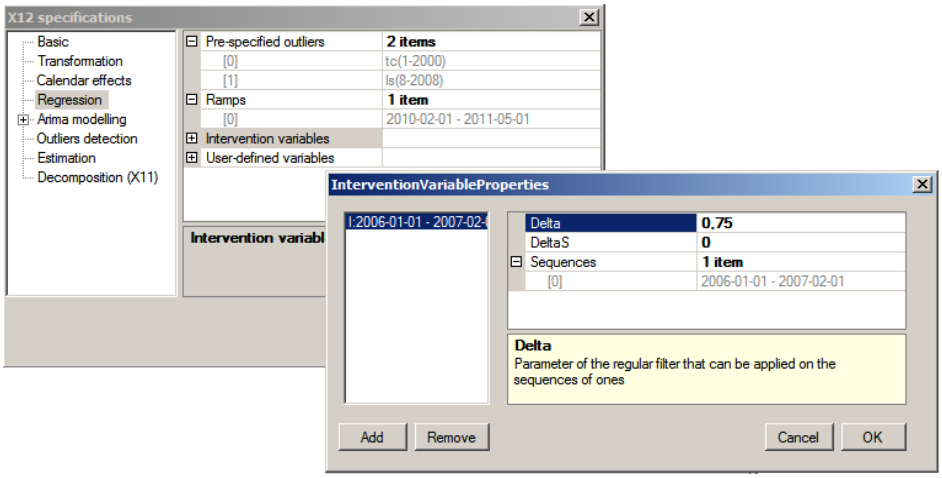


12 The user can find more details and examples in MARAVALL, A. (2008).

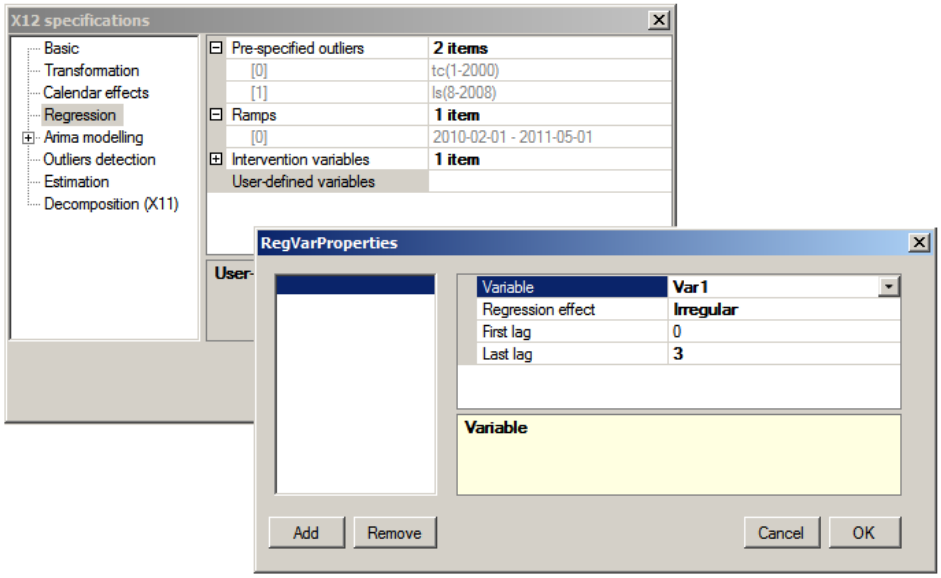
Example: Ramps



Example: Intervention variables



Example: User-defined variables

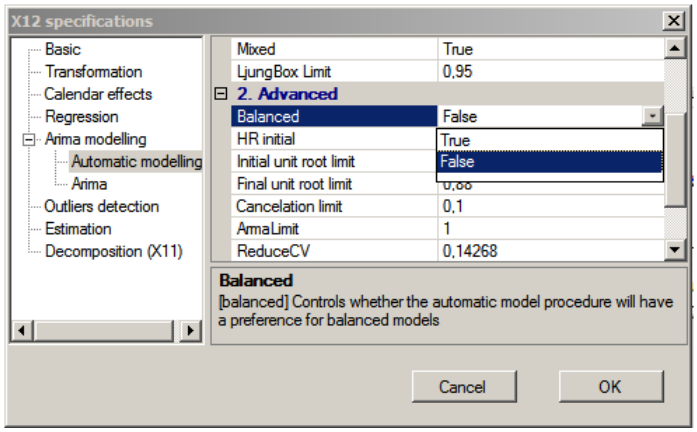


4.1.6. Automatic modelling

Item	X12		Comments
	Individual spec	**Argument**	
IsEnabled	*automdl*		Presence or not of the automdl individual spec
Accept default	*automdl*	*acceptdefault*	Controls weather the default model is chosen if the Ljung-Box Q statistics for its model residuals is acceptable
Check Mu	*automdl*	*checkmu*	Controls weather the automatic model selection procedure will check for the significance of a constant term
Mixed	*automdl*	*mixed*	Controls weather Arima models with nonseasonal AR and MA terms will be considered in the automodel
LjungBox limit	*automdl*	*ljungboxlimit*	Acceptance criterion for confident of the Ljung-Box Q statistic
Balanced	*automdl*	*balanced*	Controls weather the automatic model procedure will have a preference for balanced model
HR initial	*automdl*	*hrinitial*	Control weather Hannan-Rissanen [13] estimation is done before exact maximum likelihood estimation to provide initial values
Initial unit root limit	*automdl*		Threshold value for the initial unit root test in the automatic differencing procedure
Final unit root limit	*automdl*		Threshold value for the final unit root test in the automatic differencing procedure. This value should be greater than one.
Cancelation limit	*automdl*		Cancellation limit for AR and MA roots[14]
ArmaLimit	*automdl*	*armalimit*	Threshold value for t-statistics of Arima coefficients used for final test of model parsimony
ReduceCV	*automdl*	*reducecv*	The percentage by which the outlier critical value will be reduced when an identical model is found to have a Ljung-Box statistic with an unacceptable confidence coefficient
Reduce SE	*automdl*	unavailable	Percentage reduction of SE
Unit root limit	*automdl*	*urfinal*	Unit root limit for final model. Should be >1

13 According to GÓMEZ, V., and MARAVALL, A. (2001), the Hannan-Rissanen method is a penalty function method based on BIC (Bayesian Information Criterion) where the estimates of ARMA model parameters are computed by means of linear regressions. These estimates are computationally cheap and have similar properties to those obtained by Maximum Likelihood.

14 Cancellation problem is presented in the Annex (Chapter 7A).



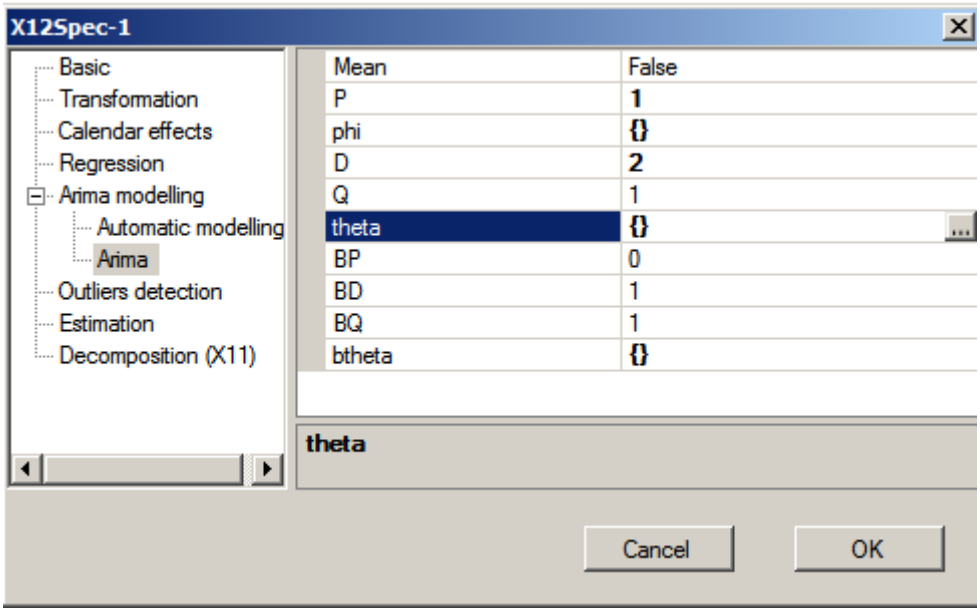
4.1.7. Arima

Options included in this section are active only if *IsEnabled* parameter from Automatic modeling section is set to false. In this window the user can specify the parameters of Arima model manually by setting P, D, Q, BP, BD, BQ values. The estimation of parameters' value is iterative. For each autoregressive and moving average parameters the user can specify its initial value used in this estimation.

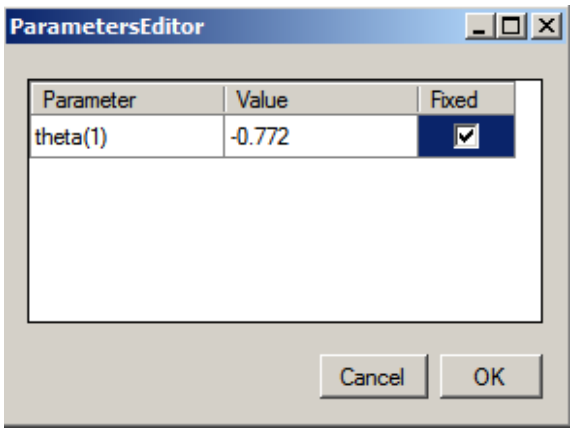
Item	X12		Comments
	Individual spec	Argument	
Mean	regression	variables	It is considered that the mean is part of the Arima model (it highly depends on the chosen model).
P, D, Q, BP, BD, BQ	arima	model	Parameters of "Box-Jenkins" Arima model $(P,D,Q)(BP,BP,BQ)$ P – nonseasonal autoregressive order D – nonseasonal differencing of order D Q – nonseasonal moving average order BP – seasonal autoregressive order BD – seasonal differencing of order BD BQ – seasonal moving average order
theta, btheta, phi, bphi	arima		theta – initial values [15] for nonseasonal seasonal autoregressive parameters phi – initial values for nonseasonal autoregressive parameters btheta – initial values for seasonal autoregressive parameters bphi – initial values for seasonal moving average parameters

The user can choose the Arima model manually In the example below Arima model (1,2,1)(0,1,1) has been specified.

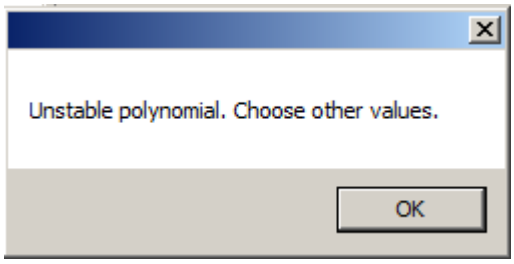
15 Initial values are described in the Annex (Chapter 6A).



The value of each parameter can be estimated automatically by the program (using initial value if specified) or fixed by the user at initial value. In order to introduce fixed parameter's value the user should click on the parameter name and then choose the button on the left-hand side, as it is shown on the picture above. Then, put the parameter value (using decimal point if necessary) and mark *Fixed* option.

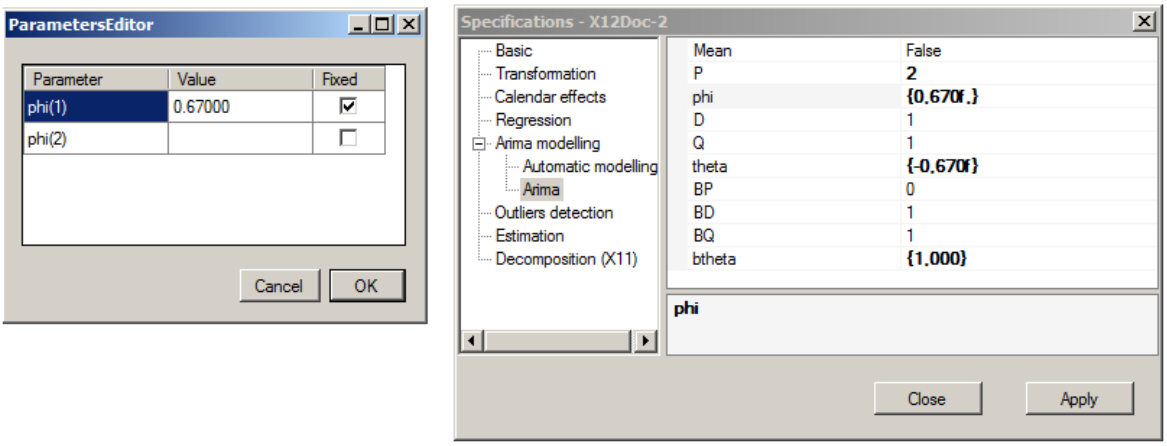


If the initial value yields an unstable[16] polynomial Demetra+ displays a warning.



16 The unstable estimate means that slight changes in input data lead to large changes in estimates. This situation takes place if estimates are highly correlated.

The example below shows the Arima (2,1,1)(0,1,1) model specified by the user. For phi(1), theta(1) and btheta(1) the user introduced the initial values. Moreover phi(1) and theta(1) values are fixed. It is not compulsory to specify initial values for all parameters. If the user changes the Arima parameters for active processing, the model will be re-estimating and results will be updating after using *Apply* button.



ARIMA model [(2,1,1)(0,1,1)]

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
Phi(1)	0,6700			
Phi(2)	0,1812	0,0627	2,89	0,0043
Th(1)	-0,6700			
BTh(1)	-0,2250	0,0625	-3,60	0,0004

For fixed parameters standard error, T-Stat and P-value are not computed.

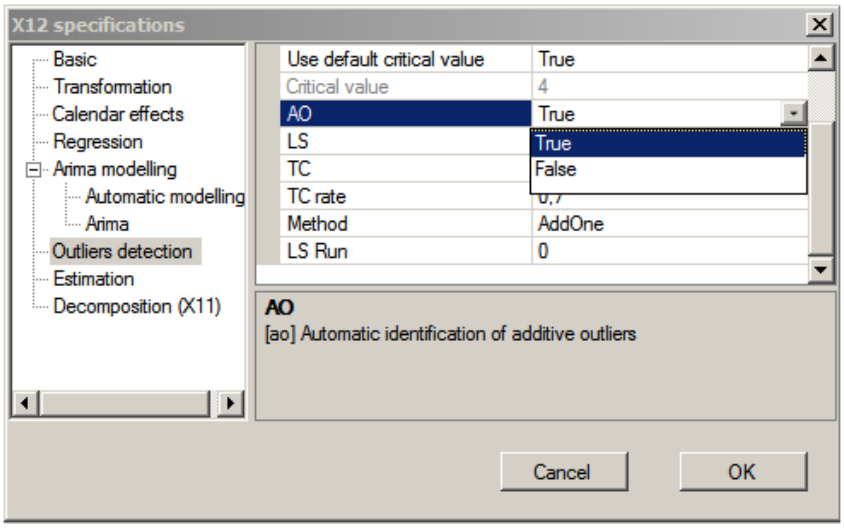
4.1.8. Outliers detection

Both X12 and TramoSeats detect outliers, which are defined as the abrupt changes that cannot be explained by the underlying normality of the Arima model. Three outliers' types can be automatically detected:

- additive outlier (AO) which affects an isolated observation;
- level shifts (LS), which implies a step change in the mean level of the series;
- temporary (transitory) change (TC), which describes a temporary effect on the level of series after a certain point in time[17].

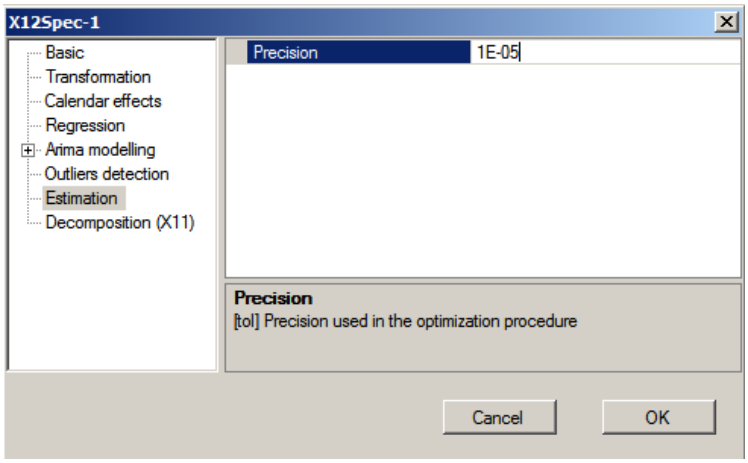
17 KAISER, R., and MARAVALL, A. (2000).

Item	X12		Comments
	Individual spec	**Argument**	
IsEnabled	*outlier*		Presence or not of the outlier individual spec
Outliers detection span	*outlier*	*span*	Span used for the outlier detection. The span can be computed dynamically on the series (for instance "Excluding last 12 obs")
Use default critical value	*outlier*	*critical*	When *Use default critical value* is false, the procedure uses the critical value mentioned in the specification. Otherwise, the default is used (the first case corresponds to "critical = xxx"; the second corresponds to a spec without the critical argument). It should be noted that it is not possible to define separate critical value for each outlier's type
Critical value	*outlier*	*critical*	Critical value used in the outliers detection procedure
AO	*outlier*	*ao*	Automatic identification of additive outliers
LS	*outlier*	*ls*	Automatic identification of level shifts
TC	*outlier*	*tc*	Automatic identification of transitory changes
TC rate	*outlier*	*tcrate*	Rate of decay for transitory change outlier regressor
Method	*outlier*	*method*	Determines how the program successively adds detected outliers to the model (could be add one by one (the outliers with the highest/insignificant t-statistic are added/removed at one time and the Arima model estimated and so on) or add all outliers together (all the significant/insignificant outliers are added/removed at once and the Arima model estimated and so on)
LS Run	*outlier*	*lsrun*	Compute t-statistic to test null hypotheses that each run of n *lsrun* successive level shifts cancels to form a temporary level shift



4.1.9. Estimation

Item	X12		Comments
	Individual spec	Argument	
Precision	*estimate*	*tol*	Precision used in the optimization procedure



4.1.10. Decomposition (X11)

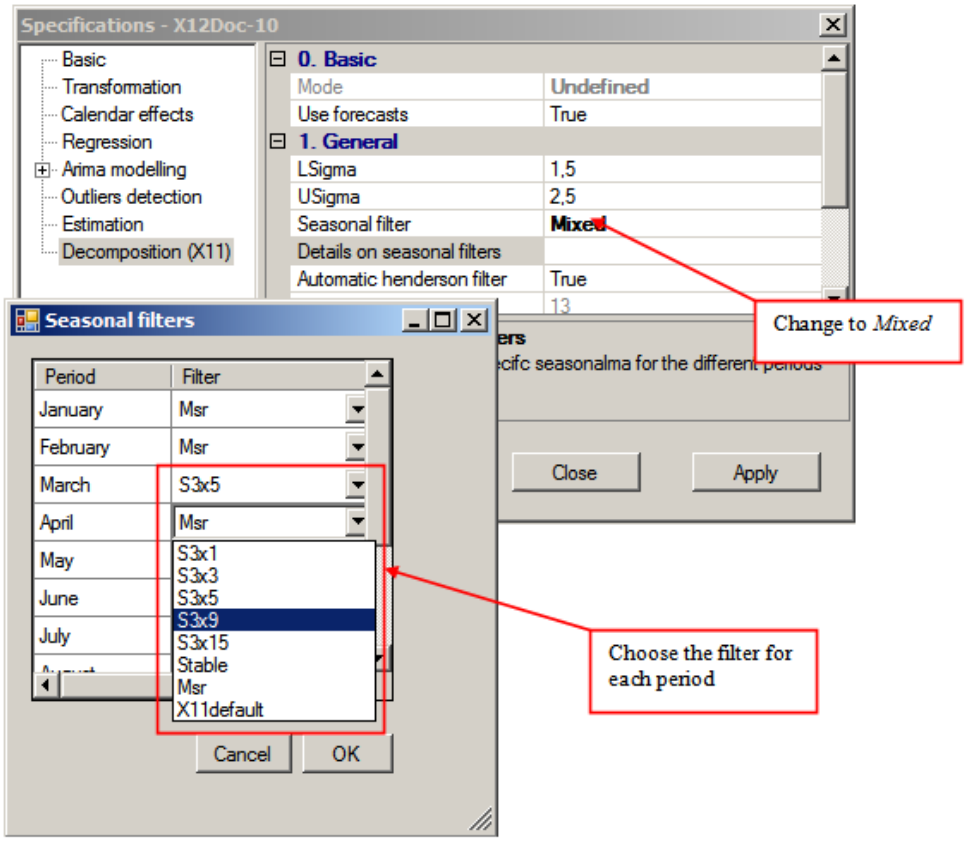
Item	X12		Comments
	Individual spec	Argument	
Mode	*x11*	*mode*	Only multiplicative, additive or logAdditve mode is possible. Pseudo-additive mode is not supported. If the transformation is set to "Log" mode can be set into "Multiplicative" or "LogAdditve". If the transformation is set to "None" Mode is automatically set to "Additive". If the transformation is set to "Auto" Mode is automatically set to "Undefined"
Use forecasts	*forecast*	*maxlead*	When *UseForecasts* is false, *maxlead* is set to 0 and the x11 procedure doesn't use any model-based forecasts. Otherwise, the forecasts of the RegArima model (default airline model if the user doesn't use pre-processing - see basic options) is used to extend the series
LSigma	*x11*	*sigmalim*	First parameter of *sigmalim* - lower sigma boundary for the detection of the extreme values
USigma	*x11*	*sigmalim*	Second parameter of *sigmalim* - uppersigma boundary for the detection of the extreme values
Seasonal filter	*x11*	*seasonalma*	Specifies which seasonal moving average (seasonal filter) will be used to estimate the

Item	X12		Comments
	Individual spec	**Argument**	
			seasonal factors for the entire series. The following filters are available[18]: • Mixed – enables to assign different seasonal filters to a particular month or quarter using *Details on seasonal filters*. Option. *Mixed* option available only after executing specifications using multi-processing seasonal adjustment (see description in section 4.4.2.3), • $S3\times1$ – 3×1 moving average[19], • $S3\times3$ – $S3\times3$ moving average, • $S3\times5$ – 3×5 moving average, • $S3\times9$ – 3×9 moving average, • $S3\times15$ – 3×15 moving average, • stable – a single seasonal factor for each calendar period is generated by calculating the simple average of all the values for each period (taken after detrending and outlier adjustment), • x11 default – 3×3 moving average is used to calculate the initial seasonal factors in each iteration and a 3×5 moving average to calculate the final seasonal factor, • Msr – automatic choice of seasonal filter. The seasonal filters can be selected for the entire series, or for a particular month or quarter.
Details on seasonal filters	*x11*	unavailable	Enable to assign different seasonal filter for each period. Option is active if *seasonalma= Mixed.* List of available options is the same as for *Seasonal filter* item (apart from *Mixed* option)
Automatic Henderson filter	*x11*	*trendma*	Automatic selection of the Henderson filter is used when the corresponding item is selected. Otherwise, the length given by the user is used.
True 7 Term	*x11*	*true7term*	Specifies the end weights used for the seven term Henderson filter
Calendar Sigma	*x11*	*calendarsigma*	Specifies if standard errors used for extreme values detection and adjustment are computed separately for each calendar period (month, quarter) or separately for two complementary sets of calendar periods.

18 'X-12-ARIMA Reference Manual' (2007).

19 LADIRAY, D., and QUENNEVILLE B. (1999),

Item	X12		Comments
	Individual spec	Argument	
Sigma Vector	*x11*	unavailable	Specifies one of the two groups of periods for whose irregulars a group standard error will be calculated under the *calendarsigma*="Select" option



4.2. TramoSeats specifications

TramoSeats specification is based on the original program (taking into account that peripheral specifications or specifications related to diagnostics are handled in a different way).

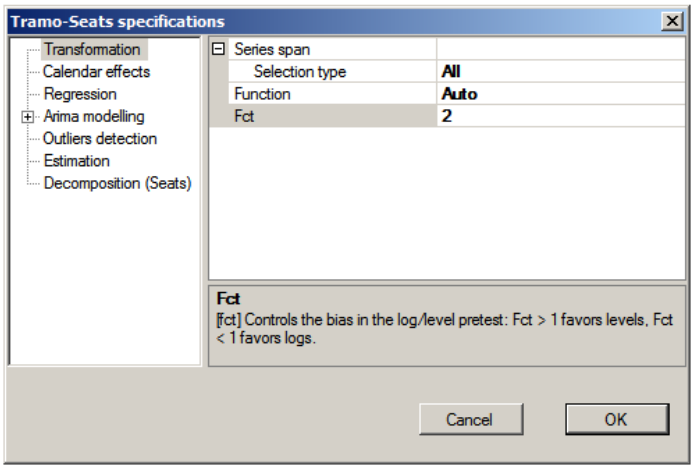
The different parts of the specification are presented in order in which they are displayed in the graphical interface of Demetra+. Details on the links between each item and its corresponding X12 spec/argument are provided in the following paragraphs. For an exact description of the different parameters, the user should refer to the documentation of the original TramoSeats program.

4.2.1. General description

Item	TramoSeats parameters	Meaning
Transformation	*Arima Model - Others*	Transformation of the original series
Calendar effects	*Others – TradingDay/Easter Effect*	Specification of the part of the regression related to calendar
Regression	*Others - ireg*	Specification of the part of the regression which is not specifically related to calendar
Automatic modelling	*Others - automatic model identification*	Automatic model identification
Arima	*Others - Arima dimension, parameters, fixed parameters*	Arima modelling
Outliers detection	*Others - Outliers*	Automatic outliers detection
Estimation	*Arima model – others*	Options on the estimation procedure of the Seats model
Decomposition (Seats)	*Others – Seats parameters*	Seats decomposition

4.2.2. Transformation

Item	TramoSeats		Comments
	Individual spec	Argument	
Series span			Span used for the processing. The span can be computed dynamically on the series (for instance "Last 90 obs")
Function	Arima model - Others	*lam*	Transformation of data: logarithm , level (none) or log/level pretest
Fct	Arima model - Others	*fct*	Control of the bias in the log/level pretest (the function is active if *Function=Auto)*; *fct* > 1 favors levels, *fct* < 1 favors logs



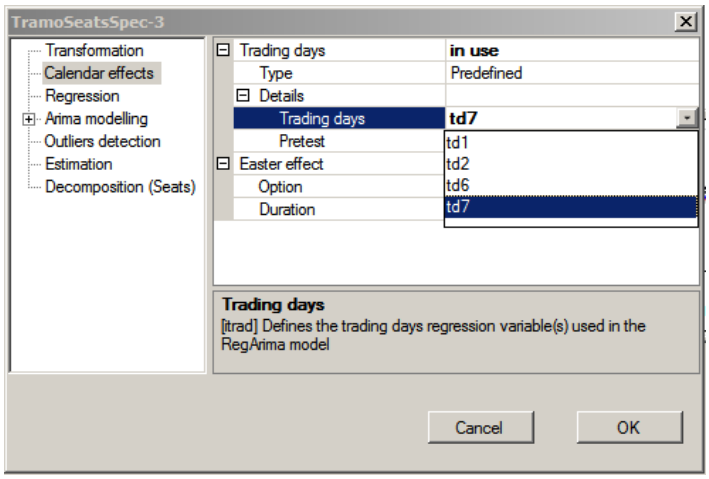
4.2.3. Calendar effects

Item	TramoSeats		Comments
	Individual spec	**Argument**	
Trading days -> Type	*Others – TradingDay/Easter Effect*	*itrad*	The user can choose between: • None, • Predefined, • Calendar, • UserDefined. "None" means that calendar effects will not be included in the regression, "Predefined" means that default calendar will be used, "Calendar" corresponds to the pre-defined trading days variables, modified to take into account specific holidays. It means that the user should specify the type of trading days effect (td1,td2, td6 or td7) and chose calendar which will be used for holidays' estimation; "UserDefined" is used when the user wants to specify in a free way his own trading day variables. With this option the calendar effect is captured only by regression variables chosen by user from the previously created User defined variables (see: 3.1.2).
Trading days-> Details -> Trading days (option is available if Trading days ="Predefined"	*regression*	*variables*	Acceptable values: • td1 – includes the weekday-weekend contrast variable, • td2 – includes the weekday-weekend contrast variable and a leap year effect, • td6 – includes the six day-of-the week variables,

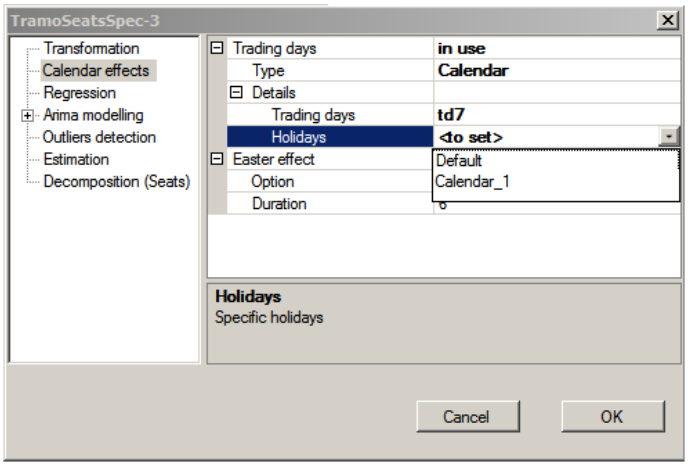
Item	TramoSeats		Comments
	Individual spec	**Argument**	
or "Calendar type")			• td7 – includes the six day-of-the week variables and a leap year effect
Trading days -> Pretest	*Others – TradingDay/Easter Effect*	*itrad*	Pretest of the trading days correction. Option available for *type*="Predefined"
Trading days-> Details -> Holidays (option is available if Trading days = "Calendar type")	*Others - ireg*	*regeff, iuser, ilong, nser*	When the user chooses the "calendar" type for the trading days, the corresponding holidays should be specified. It should be noted that such a holiday must have been previously defined (see 3.1.1)
Trading days-> Details -> Items (option is available if Trading days = "UserDefined")	*Others - ireg*	*regeff, iuser, ilong, nser*	When the user chooses for the trading days the type="UserDefined", the corresponding variables should be specified. It should be noted that such variables should have been previously defined (see 3.1.2)
Easter (IsEnabled)	*Others - TradingDay/Easter Effect*	*ieast*	The option enables the user to treat the Easter effect in three different ways. The user can choose between: • No, • Pretest, • Yes. "No" – a correction for Easter effect is not performed, "Pretest" – Demetra+ estimates the Easter effect if statistical tests shows that this effect is significant, "Yes" – the correction for Easter effects is performed. For last two option the user can modify the default length of the Easter effect (default length is 6 days)
Duration	*Others – TradingDay/Easter Effect*	*idur*	Duration of the Easter effect (w parameter of the "easter" variable). The parameter is active if the *iest*="Pretest" or "Yes".

The current version of Demetra+ doesn't allow the use of stock trading days. Pre-defined calendar day for the handling of *Labor Day* and of *Thanksgiving* are not available (see 3.1.1. for list of pre-defined holidays). Nevertheless the user is allowed to create any fix day regression variable.

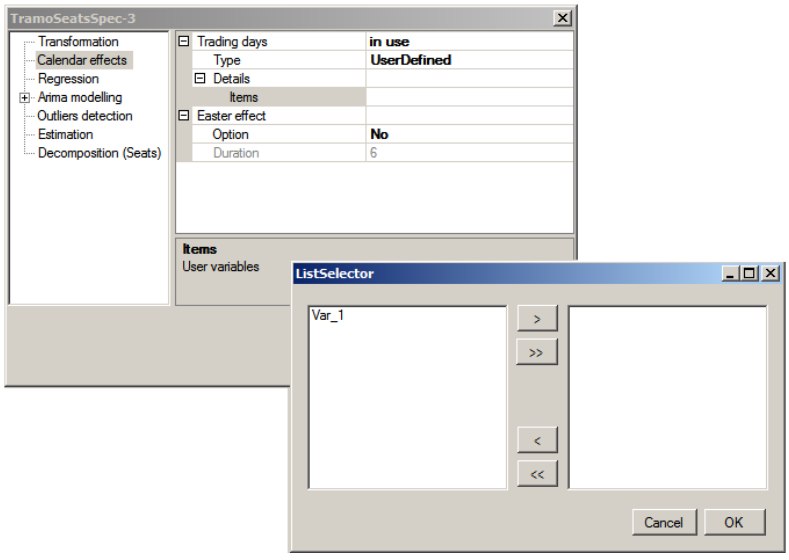
Example: predefined trading days



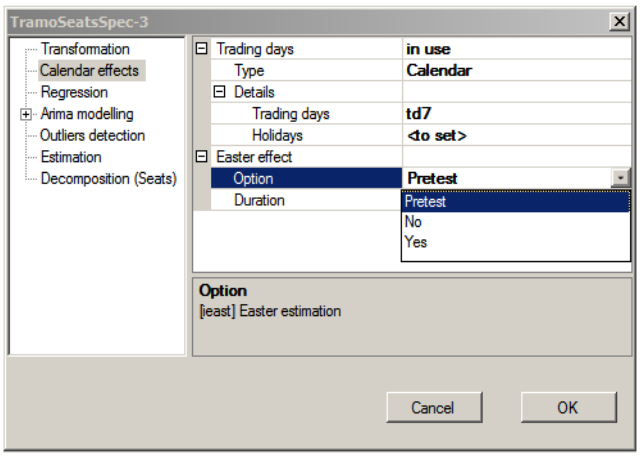
Example: calendar trading days



Example: user-defined trading days



Example: Easter effect



4.2.4. Regression

Item	TramoSeats		Comments
	Individual spec	**Argument**	
Pre-specified outliers	*Others - others*	*ireg, iuser, nser*	User-defined outliers are used if prior knowledge suggest that such effects exist at known time points[20]: • Additive Outlier (AO) – additive, point outlier which occurred in a given date t_0 . It is modeled by variable $AO_t^{t_0} = \begin{cases} 1 \; for \; t = t_0 \\ 0 \; for \; t \neq t_0 \end{cases}$, • Level shift (LS) – variable for a constant level shift beginning on the given date t_0 . It is modeled by regression variable $LS_t^{t_0} = \begin{cases} -1 \; for \; t < t_0 \\ 0 \; for \; t \geq t_0 \end{cases}$, • Temporary change[21] (TC) – a variable for a temporary level change beginning on the given date t_0. It is modeled by regression variable $TC_t^{t_0} = \begin{cases} 0 \; for \; t < t_0 \\ \alpha^{t-t_0} \; for \; t \geq t_0 \end{cases}$,

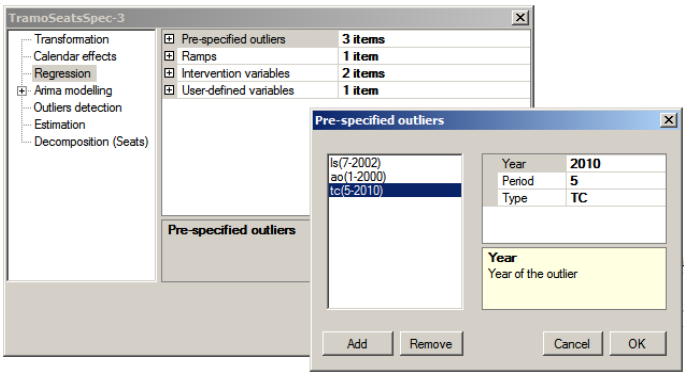
20 Definitions from: 'X12-ARIMA Reference Manual', (2007).
21 In TramoSeats method this type of outlier is sometimes called by transitory change.

Item	TramoSeats		Comments
	Individual spec	**Argument**	
			where α is a rate of decay back to the previous level $(0 < \alpha < 1)$. Seasonal outliers are not supported. Pre-specified outliers are simple forms of intervention variables.
Ramps	*Others - others*	*ireg, ilong, delta, iseq, regeff*	Ramp effect means a linear increase or decrease in the level of the series over a specified time interval from t_0 to t_1. It is modeled by regression variable $RP_t^{(t_0,t_1)} = \begin{cases} -1 \ for \ t \le t_0 \\ (t-t_0)/(t_1-t_0)-1 \ for \ t_0 \le t < t_1 \\ 0 \ for \ t \ge t_1 \end{cases}$. All dates of the ramps must occur within the time series. Ramps can overlap other ramps, additive and level shifts outliers.
Intervention variables	*Others - others*	*ireg, nser, ilong, deltas, id1ds, iseq, regeff*	The intervention variables are special events known a-priori (strikes, devaluations, political evens, and so on). Intervention variables are modeled as any possible sequence of ones and zeros, on which some operators may be applied. This option enables the user to define four types of intervention variables: • Dummy variables, • Any possible sequence of ones and zeros, • $\frac{1}{(1-\delta B)}$ of any sequence of ones and zeros $(0 < \delta(Delta) \le 1)$, • $\frac{1}{(1-\delta_s B^s)}$ of any sequence of ones and zeros $(0 < \delta_s(DeltaS) \le 1)$.
User-defined variables	*Others - others*	*ireg, iuser, nser, regeff*	The user-defined variables effect can be assigned to the trend, irregular, holiday or can exist as an additional component (option "Undefined". For practical considerations, seasonal effects are currently not supported. The user can specify the structure of the lags[22]. When regression variable *Var* is introduced a with *first lag* = l_a and *last lag* = l_b, Demetra+

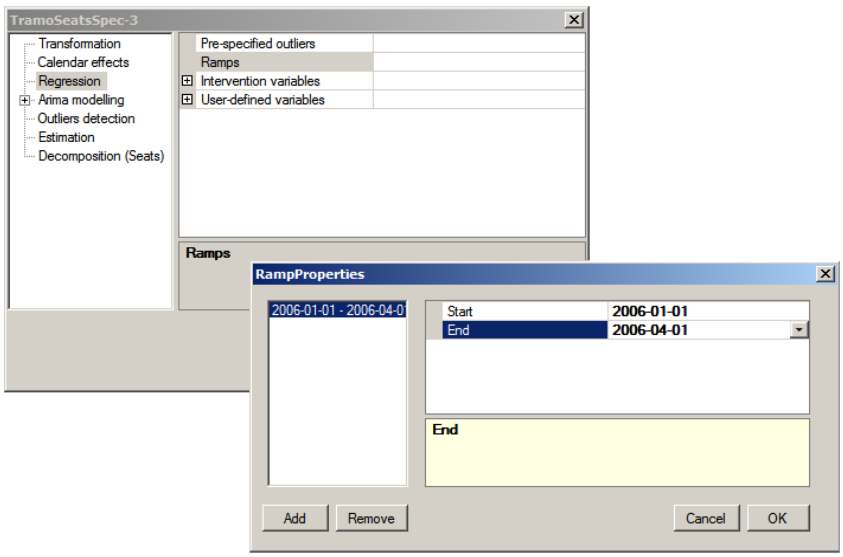
22 The user can find more details and examples in MARAVALL, A. (2008).

Item	TramoSeats		Comments
	Individual spec	Argument	
			estimates the following regression model for this variable: $Var_t = \beta_a x(t-l_a) + ... + \beta_b x(t-l_b)$ To estimate $Var_t = \beta_1 x(t-l_1)$ The user should put *first lag* = *last lag* = 1. If put *first lag* = 0 and *last lag* = 12 it means that in addition to instantaneous effect, the effect of variable *Var* is spread over one year.

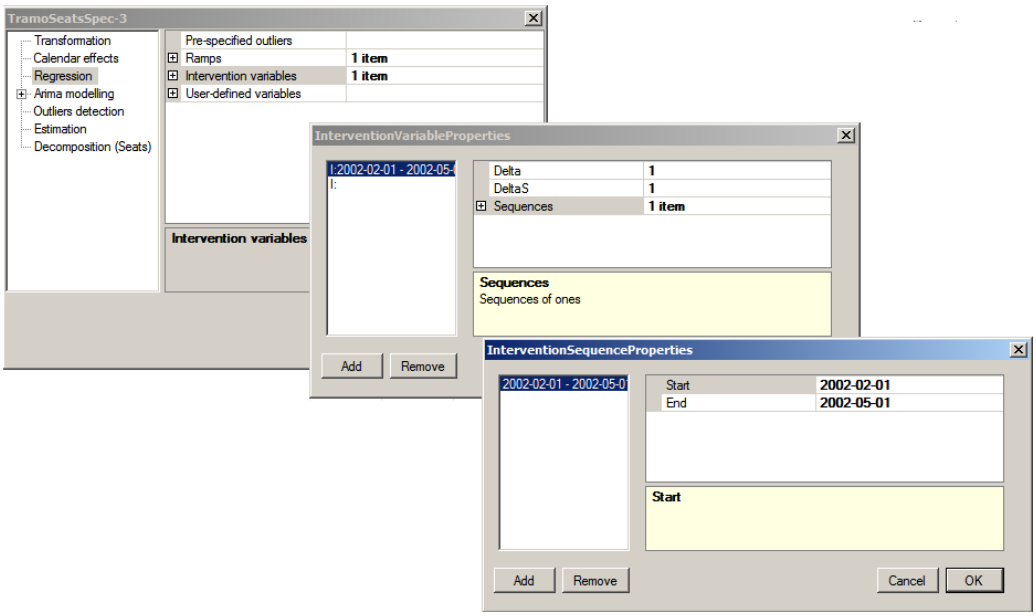
Example: Pre-specified outliers



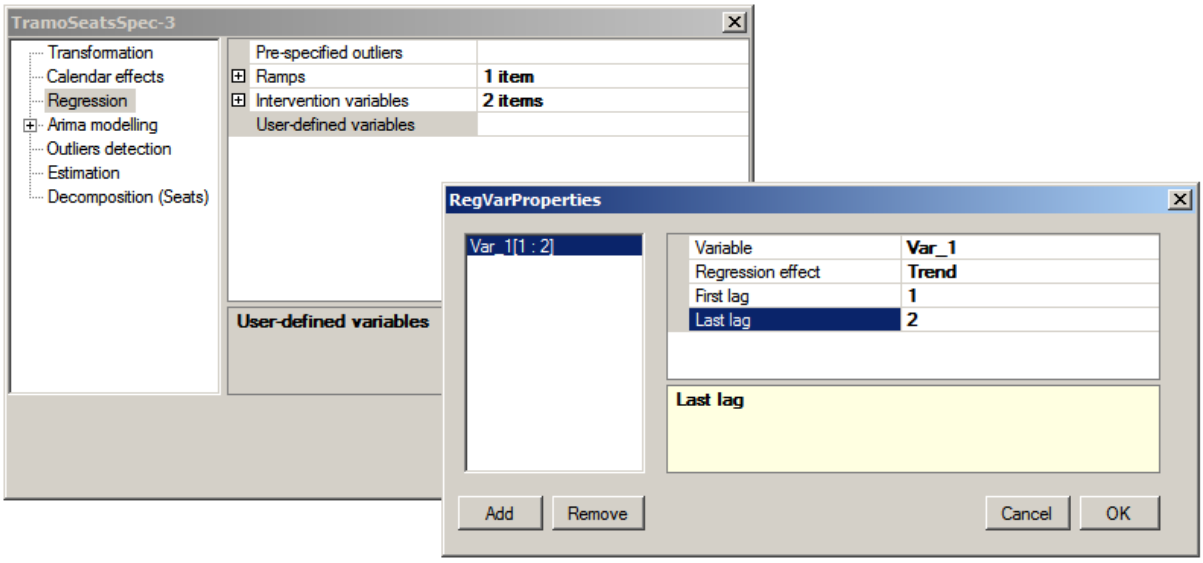
Example: Ramps



Example: Intervention variables



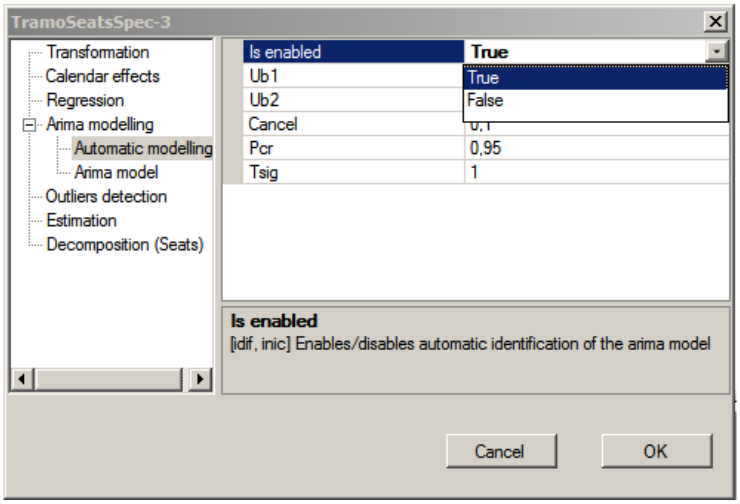
Example: User-defined variables



4.2.5. Arima modelling - automatic modelling

Item	TramoSeats		Comments
	Individual spec	**Argument**	
IsEnabled	*Others - Automatic model identification*	*inic, idif*	Presence or not of the automdl individual spec
Ub1	*Arima model – Unit roots*	*ub1*	Initial unit root limit in the automatic differencing procedure. Ub1 is advanced and rarely used option used in the detection of

Item	TramoSeats		Comments
	Individual spec	Argument	
			unit roots in Tramo. It is is used as a threshold to detect unit roots in the first step of the automatic identification of the differencing polynomial, which consists in the estimation of a $(2,0,0)(1,0,0)$ plus mean Arma model
Ub2	*Arima model – Unit roots*	*ub2*	Final unit root limit in the automatic differencing procedure. Ub2 is advanced and rarely used option used in the detection of unit roots in Tramo. It is used in the next steps of estimating procedure based on the estimation of $(1,d,1)(1,bd,0)$ plus mean Arma models
Cancel	*inic, idif*	*cancel*	Cancellation limit for AR and MA roots[23]
Pcr	*Others - Automatic model identification*	*pcr*	Ljung-Box Q statistic limit for the acceptance of a model
Tsig	*Others - Automatic model identification*	*tsig*	Minimum t for significant mean



4.2.6. Arima model

Options included in this section are active only if *IsEnabled* parameter from Automatic modeling section is set to false.

23 Cancellation issue is described in the Annex (Chapter7A).

Item	TramoSeats		Comments
	Individual spec	Argument	
Mean	Arima model - Others	imean	It is considered that the mean (a constant term) is part of the Arima model (it highly depends on the chosen model)
P, D, Q, BP, BD, BQ	Arima model - Arima dimension	P, D, Q, BP, BD, BQ, init	Parameters of "Box-Jenkins" Arima model $(P,D,Q)(BP,BP,BQ)$ P – regular l autoregressive order D – regular differencing of order D Q – regular moving average order BP – seasonal autoregressive order BD – seasonal differencing of order BD BQ – seasonal moving average order
theta, btheta	Arima model – Arima parameters - Arima fixed parameters	*[th, jqr]* *[bth, jqs]*	theta – initial (fixed) values[24] for regular moving average parameters btheta – initial (fixed) values for seasonal moving average parameters
phi, bphi	Arima model – Arima parameters, Arima fixed parameters	*[phi, jpr]* *[bphi, jps]*	phi – initial (fixed) values for nonseasonal autoregressive parameters bphi – initial (fixed) values for seasonal moving average parameters

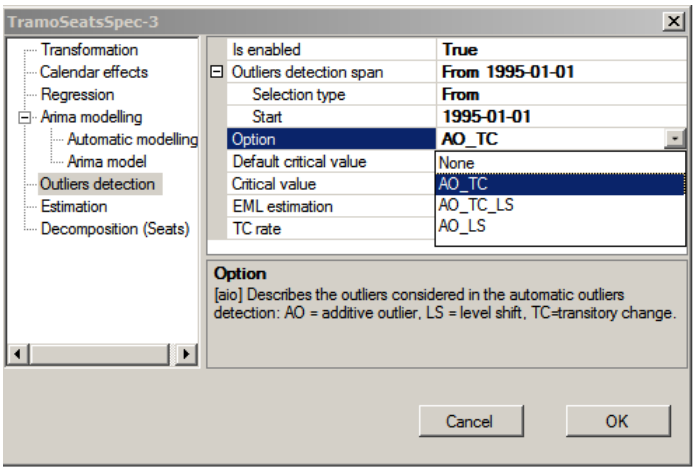
Imputation of initial values of parameters in Demetra+ is the same for TramoSeats and X12. For description refer to 3.2.7.

4.2.7. Outliers detection

Item	TramoSeats		Comments
	Individual spec	Argument	
IsEnabled	*Others - outliers*	*iatip*	Presence or not of the outlier individual spec
Outliers detection span	*Others - outliers*	*int1, int2*	Span used for the outlier detection. The span can be computed dynamically on the series (for instance "Excluding last 12 obs")
Option	*Others - outliers*	*aio*	Describes the outliers considered in the automatic outliers detection. It is possible to detect all types of outliers, only AO (additive outliers) and TC (transitory change), or only AO and LS
Default critical value	*Others - outliers*	*va*	When "*Use default critical value*" is false, the procedure uses the critical value imposed by the user. Otherwise, the default is used (the first case corresponds to "critical = xxx"; the second corresponds to a spec without the

24 Initial values are described in the Annex (Chapter 6A).

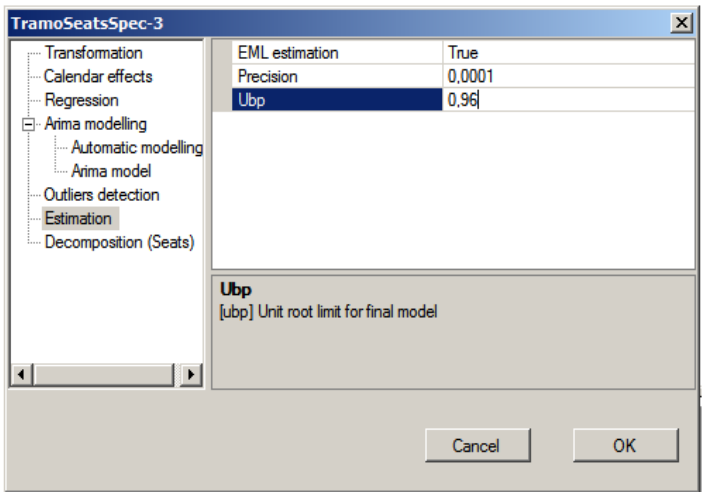
Item	TramoSeats		Comments
	Individual spec	Argument	
			critical argument). It should be noted that it is not possible to define different critical values for different outliers' types
Critical value	*Others - outliers*	*va*	Critical value used in the outliers' detection procedure
TC rate	*Others - outliers*	*deltatc*	Rate of decay for transitory change outlier regressor
EML estimation	*Others - outliers*	*imvx*	True if exact likelihood estimation method is used, false if fast Hannan-Rissanen[25] method is used



4.2.8. Estimation

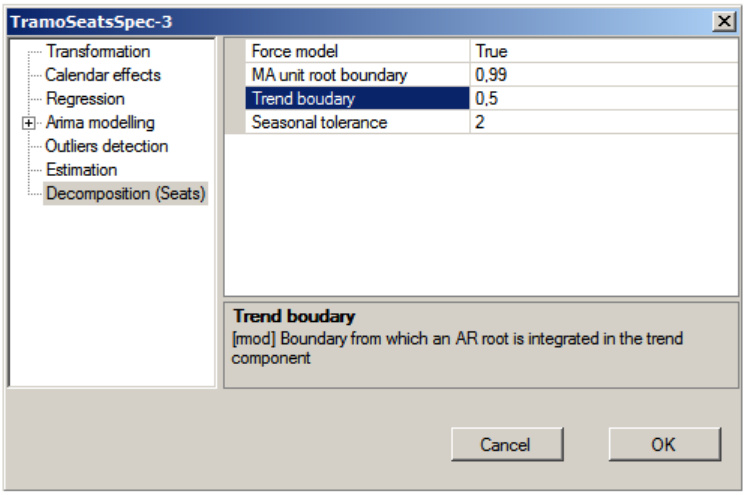
Item	TramoSeats		Comments
	Individual spec	Argument	
EML estimaton	*Arima model - others*	*type*	True if exact maximum likelihood (for SEATS and TRAMO) is used, false if least squares (conditional for seats, unconditional for tramo) is used
Precision	*Arima model*	*tol*	Precision used in the optimization procedure
Udp	-	-	Unit root limit for final model

25 See the Annex, section 5A.



4.2.9. Decomposition (Seats)

Item	TramoSeats		Comments
	Individual spec	Argument	
Force model	*Seats parameters*	*noadmiss*	When model does not accept an admissible decomposition, force to use an approximation
MA unit root boundary	*Seats parameters*	*xl*	When the modules of n estimated root falls in the range (*xl*,1), it is set to 1 if it is in AR; it is set equal to *xl* if root is in MA.
Trend boundary	*Seats parameters*	*mod*	Trend boundary is defined for the modulus of the AR root. If real positive root is equal or greater than that value the AR root is integrated in the trend component. Below that value the root is integrated in the transitory component.
Seasonal tolerance	*Seats parameters*	*epsphi*	Tolerance (measured in degrees) to allocate AR roots into the seasonal or the transitory component



4.3. Single processing

Demetra+ offers several ways to define seasonal adjustment of a single time series. A key question, which will determine the best way to proceed, concerns the specification that will be used to start the analysis.

4.3.1. Defining a single-processing

The first step to produce a fast seasonal adjustment is to create a processing. The user can take the existing specification or create completely new specification. First category includes pre-defined specifications and specifications previously defined and saved by the user. The second solution is to create the new specification for the needs of seasonal adjustment of particular time series. This can be done when a user wants to use in a frequent way a specification that is not available in the list of the predefined ones (for example if one wants to integrate systematically its own calendar variables or if one want to exclude some kinds of outliers). After creating a new specification it can be added to the user's workspace.

4.3.1.1. Creation of a single processing using existing specification

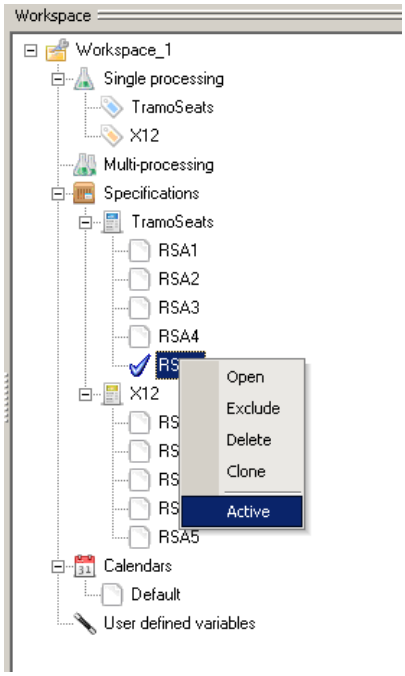
Single processing can be launched in two different ways:

1. ***by activating the specification or drag/drop the specification***

The user could activate the specification from the list displayed in the workspace panel before choosing the series. By default, RSA5c is ticked.

The procedure is as follows:

- Select in the *Workspace tree* the specification you want to activate,
- Open the local menu by means of the right button of the mouse,
- Choose the **Active** option from pop-up menu.

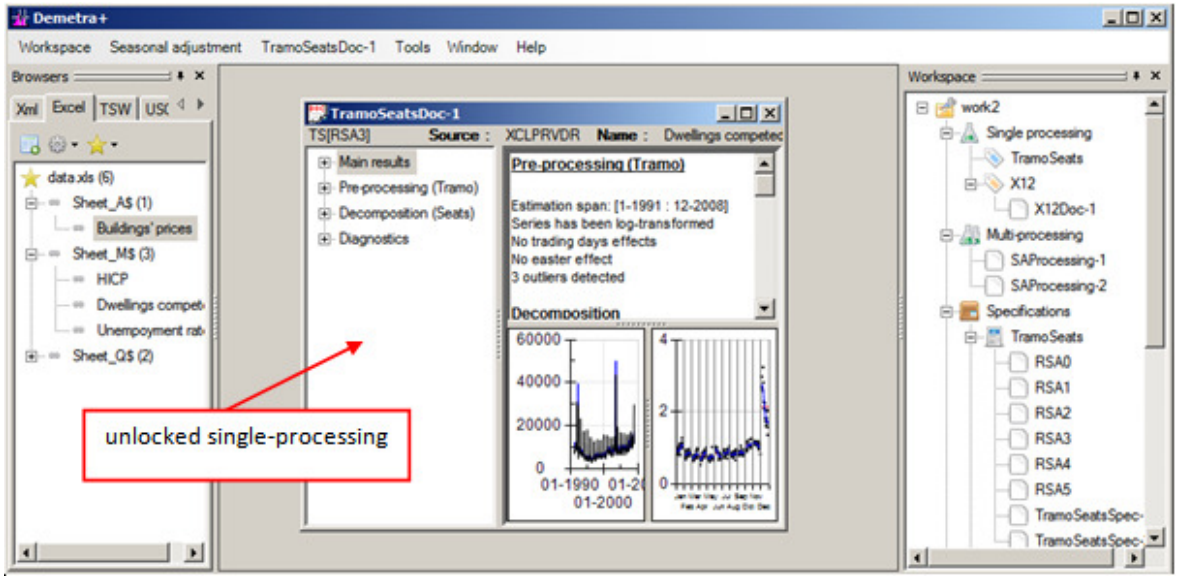


That specification, called active specification, will be used to generate the processing. This specification can be changed at any time.

When the user double-clicks a series in a browser, the software follows the following logic:

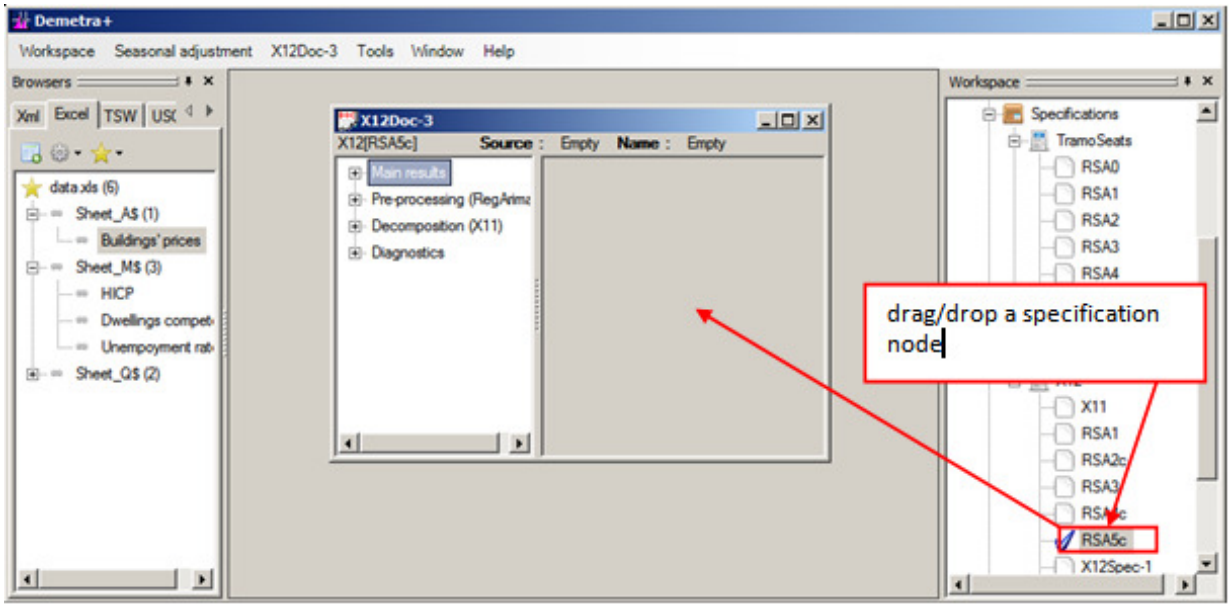
If there is an active specification in the workspace panel, then:

- If some single-processing are open (i.e. single-processing windows have been opened in the central panel), they are updated with the new series.



- If no unlocked single-processing is available, a new one is generated with the active specification.

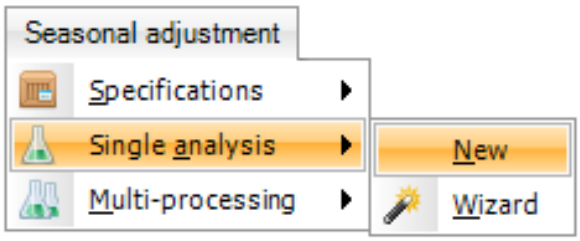
The other option is to drag any specification from the workspace panel and drop it in the central panel of the application. A new single processing window will open automatically.



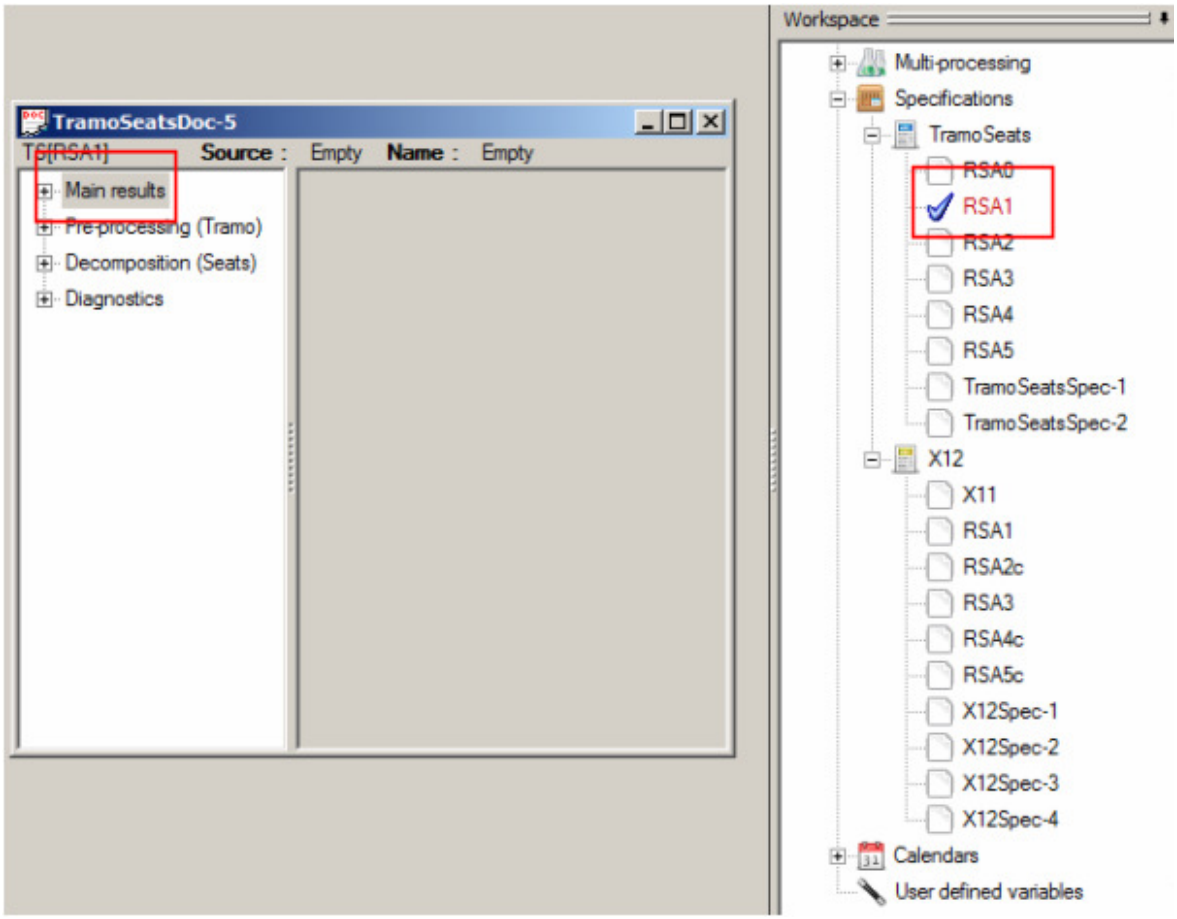
The data can be imported into specification's window either by a double click on the series of the browsers or by dragging/dropping the series in the left panel of the single processing window.

2. *by the main menu*

Other method to define single seasonal adjustment is to use the **New** option from the main menu:



Demetra+ will display a new single processing window with the active specification (the one which is ticked in the *Workspace* panel).

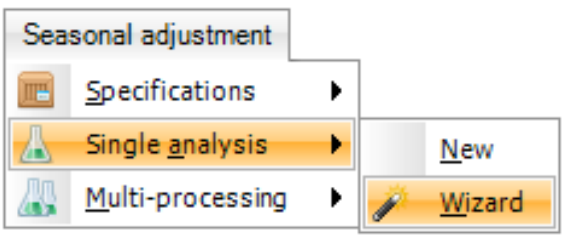


In the next step click "Choose the method" from the left-hand list and mark TramoSeats or X12. Then, choose the specification from the list of specifications (the contents of the list depends on the method chosen) or define the new one. Demetra+ displays the window with the chosen specification. The last step is to drag the time series from the browser and drop it in this window. The seasonal adjustment process is started instantly and the output is displayed in the screen.

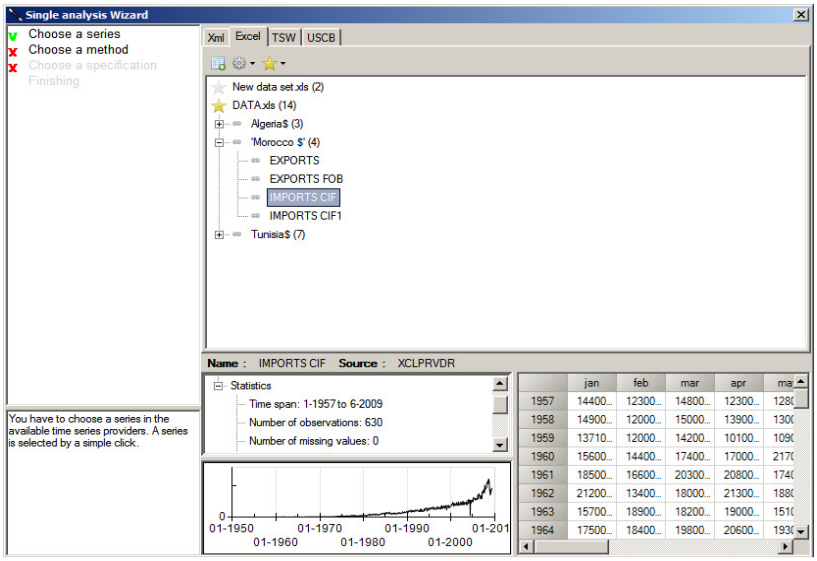
4.3.1.2. Creation of a single processing by defining new specifications

1. ***by Wizard***

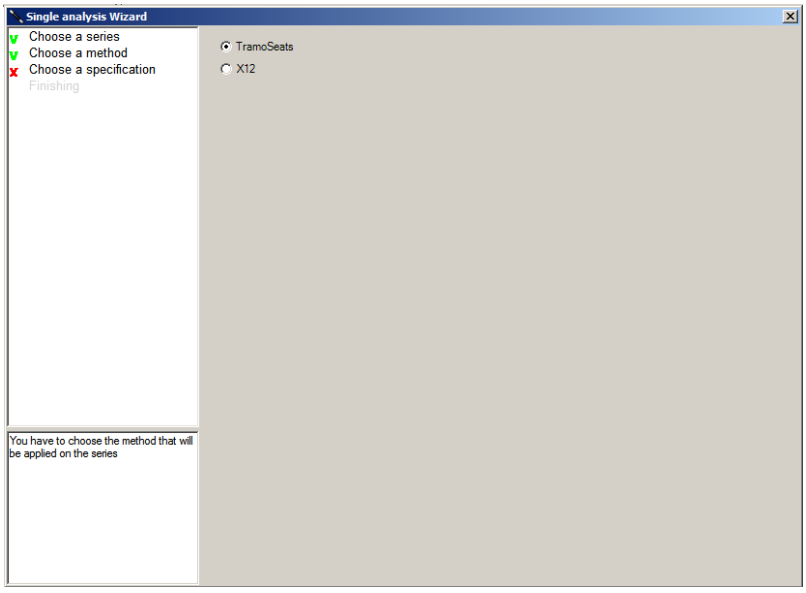
This function is activated from the main menu:



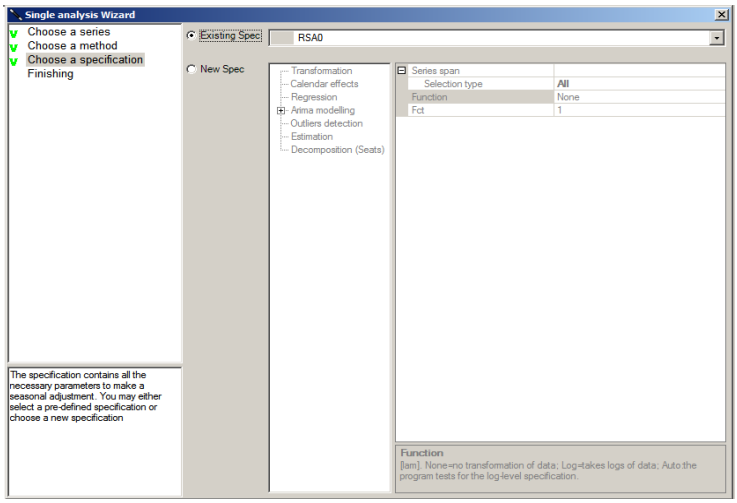
In the first step the user should choose the series one wants to analyse, using the browser:



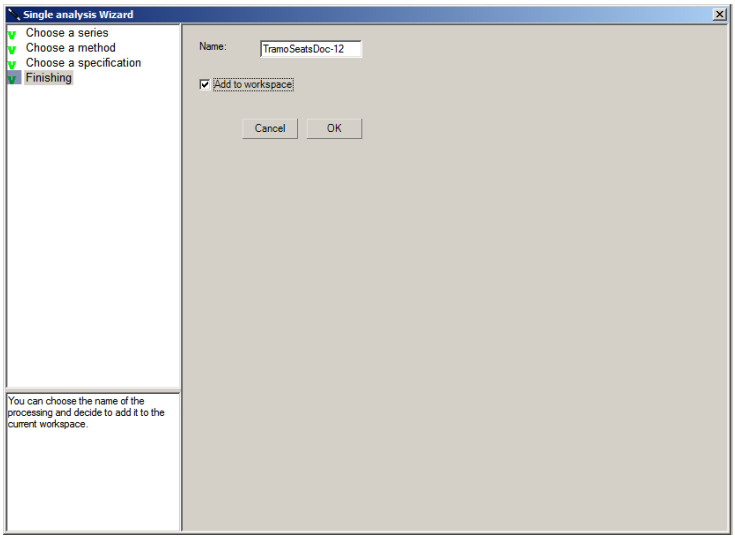
Then the methods can be selected:



After that, the user can choose the specification from the list available in the very top of the window, or create new specification. In the example below the RSA0 specification will be used for seasonal adjustment. Obviously the user can define the new specification (*New Spec* option). The specification parameters depend on the method (TramoSeats or X12) chosen in the previous step. For X12 please refer to 4.1. TramoSeats specification is described in 4.2.

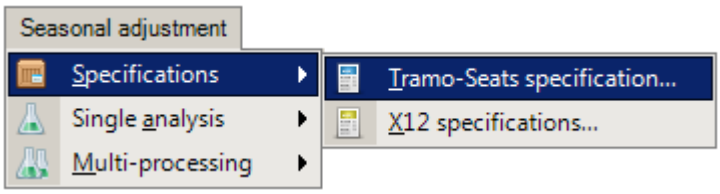


Finally click the "Finishing" item and decide if you want add it into *Workspace*.

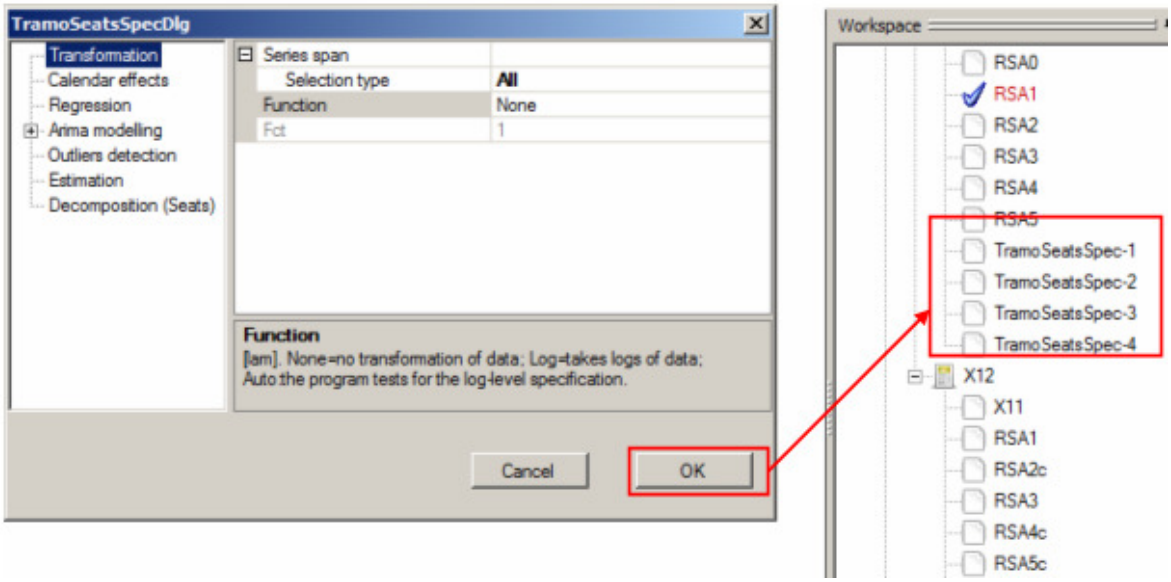


2. *by preliminary choice of the seasonal adjustment method*

Single seasonal adjustment processing can be defined by choosing TramoSeats specification or X12 specification from main menu.

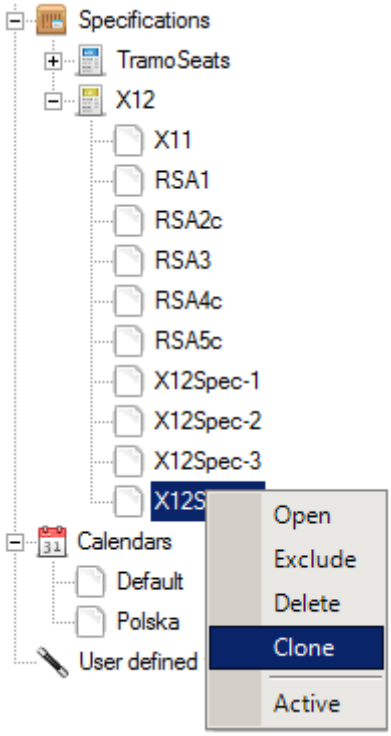


Then the new specification window will be displayed with default settings. The user is allowed to change them. After clicking *OK* button the new specification is added to the specifications' list in *Workspace* (TramoSeats or X12 specifications' list depending on initial choice).

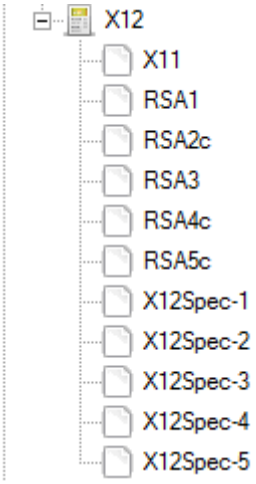


3. by cloning specification

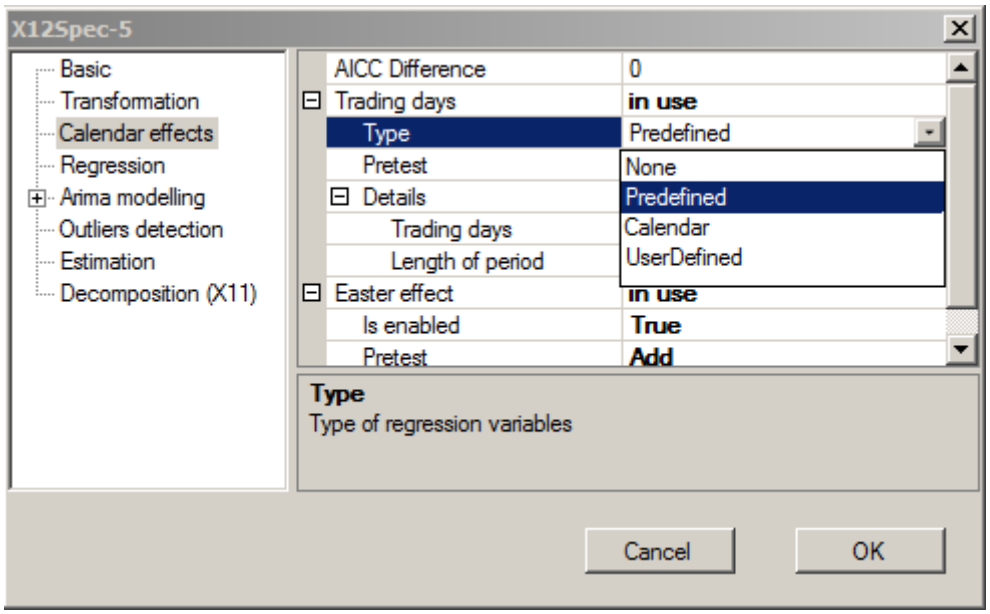
The new specification can be created directly in the Workspace window by clicking on the existing specification (pre-defined or previously created by the user) and choosing option Clone. New specification will be added to the specifications' list. The pictures below illustrate this solution. First, the option Clone has been chosen for X12 Spec-4.



Then, new specification appears on the X12 specifications list.



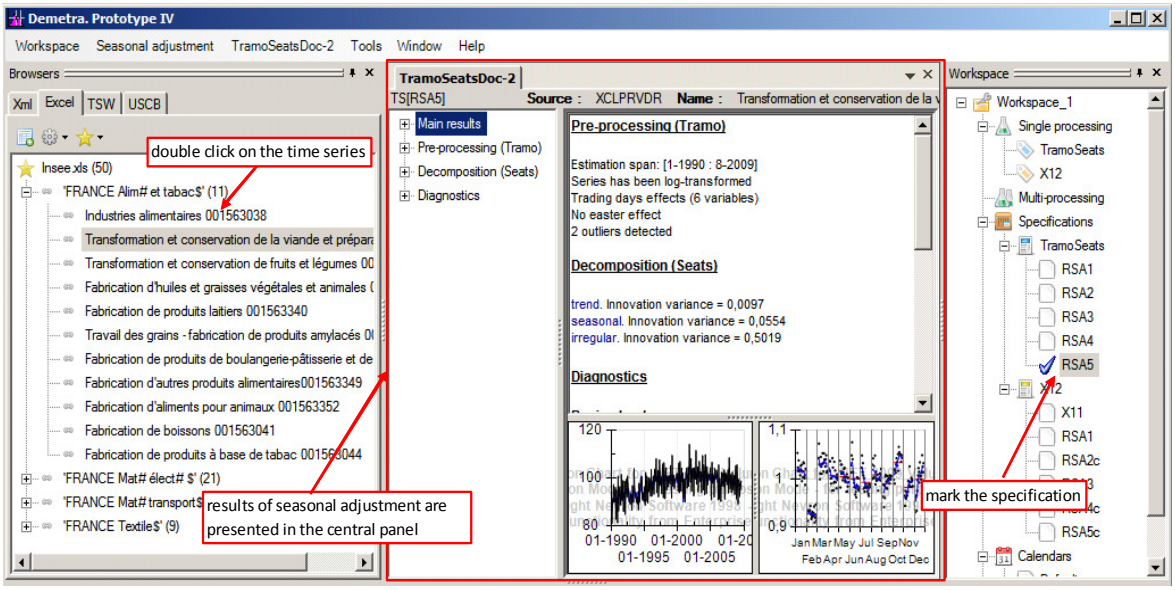
X12Spec-4 and X12Spec-5 are identical. The user can modify the settings of X12Spec-5 specification by double click on its name and changing parameters in the specification window.



All specifications created by the user can be modified at any time.

4.3.2. Seasonal adjustment results – single processing

Once the active specification is chosen, the series that will be seasonally adjusted should be double clicked. The processing is immediately initiated, using the selected specification and the chosen series.



The results contain a set of detailed panels organized in tree displayed in the left panel of the output window. The user can go through them by selecting a node in the navigation tree of the processing. The current specification and the current series are displayed on the top of the window. Demetra+ presents several charts and tables with the results of seasonal adjustment and a set of measures of the quality of seasonal adjustment.

The quality diagnostic implemented in original seasonal adjustment algorithms are different for each SA method. Moreover, their interpretation could be problematic for an unsophisticated user. For this reason, in Demetra+ the qualitative indicator was build-in. Indicator's values are described in the following table:

Meaning of the quality indicator[26]

Value	***Meaning***
Undefined	The quality is undefined because of unprocessed test, meaningless test, failure in the computation of the test, etc.
Error	There is a logical error in the results (for instance, it contains aberrant values or some numerical constraints are not fulfilled). The processing should be rejected
Severe	There is no logical error in the results but they should not be accepted for serious quality reasons
Bad	The quality of the results is bad, following a specific criterion, but there is no actual error and the results can be used
Uncertain	The result of the test shows that the quality of the seasonal adjustment is uncertain
Good	The result of the test is good from the aspect of the quality of seasonal

26 The model also contain a flag "Accepted", which simply means that the user decided to accept the results, no matter what are the different diagnostics.

	adjustment

Several qualitative indicators can be combined following the basic rules. Given a set of n diagnostics, the sum of the results is:

Sum	***Rules***
Undefined	All diagnostics are "Undefined"
Error	There is at least 1 "Error"
Severe	There is at least 1 "Severe" diagnostic but no error
Bad	No "Error", no "Severe" diagnostics; the average of the (defined) diagnostics ("Bad"=1, "Uncertain"=2, "Good"=3) is < 1.5
Uncertain	No "Error", no "Severe" diagnostics; the average of the (defined) diagnostics ("Bad"=1, "Uncertain"=2, "Good"=3) is in [1.5, 2.5[
Good	No "Error", no "Severe" diagnostics; the average of the (defined) diagnostics ("Bad"=1, "Uncertain"=2, "Good"=3) is ≥ 2.5

According to the table, "Error" and "Severe" diagnostics are absorbent results.

The quality of each diagnostics (except for "Undefined" and "Error") can be parameterized by the user in Tools->Options->Diagnostic menu.

4.3.2.1. X12

For X12 the basic output structure is as follows:

- Main results,
  - Charts,
  - Table,
  - S-I ratio,
- Pre-processing(RegArima),
  - Pre-adjustment series,
  - Arima,
  - Regressors,
  - Residulas,
- Decomposition (X-11),
  - A-Tables,
  - B-Tables,

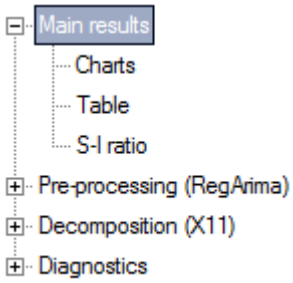
- C-Tables,
- D-Tables,
- E-tables,
- Quality measures,

- Diagnostics,
  - Seasonality tests,
  - Spectral analysis,
  - Revisions history,
  - Sliding spans,
  - Model stability.

Detailed description of the seasonal adjustment outcomes is presented below.

4.3.2.1.1. Main results

The *Main results* node includes basic information about pre-processing and the quality of the outcomes.



The first section summarises the results of Pre-processing.

Pre-processing (RegArima)

Estimation span: [1-2000 : 2-2011]
Series has been log-transformed
No trading days effects
Easter effect detected
3 outliers detected

The message "Series has been log-transformed" is displayed if a logarithmic transformation has been applied as a result of the test done by X12. Otherwise, information does not appear.

In case of X11, RSA1 and RSA3 specifications no trading days effect is estimated. For RSA2c and RSA 4c specifications working days effect and leap year effect are pretested and estimated if

present. If working day effect is significant, pre-processing part includes information "Working days effect (1 regressor)". Message "Working days effect (2 regressors)" means that also leap year effect is significant. For RSA5 trading days effect and leap year effect are pretested. If the trading days effect has been detected, message "Trading days effect (6 regressors)" or "Trading days effect (7 regressors)" is displayed, depending whether leap year effect has been detected or not. If Easter effect is statistically significant in series, "Easter effect detected" is displayed.

If X11 specification is used or any significant outliers have not been found under other specifications, information "No outliers found" is displayed. In this section only total number of detected outliers is visible. More information, i.e. type, date and coefficients of every outlier are specified in node "Pre-processing (RegArima)".

Second part of *Main Results* aims to inform the user about quality of the seasonal adjustment by reporting a summary of diagnostics. Summary, Basic Checks, Visual spectral analysis, regarima residuals, residual seasonality, outliers, m-statistics parts are described further.

In the *Charts* section the top panel presents the original series with forecasts, the final seasonally adjusted series, the final trend with forecasts and the final seasonal component with forecasts. The second panel shows the final irregular component and the final seasonal component with forecasts.

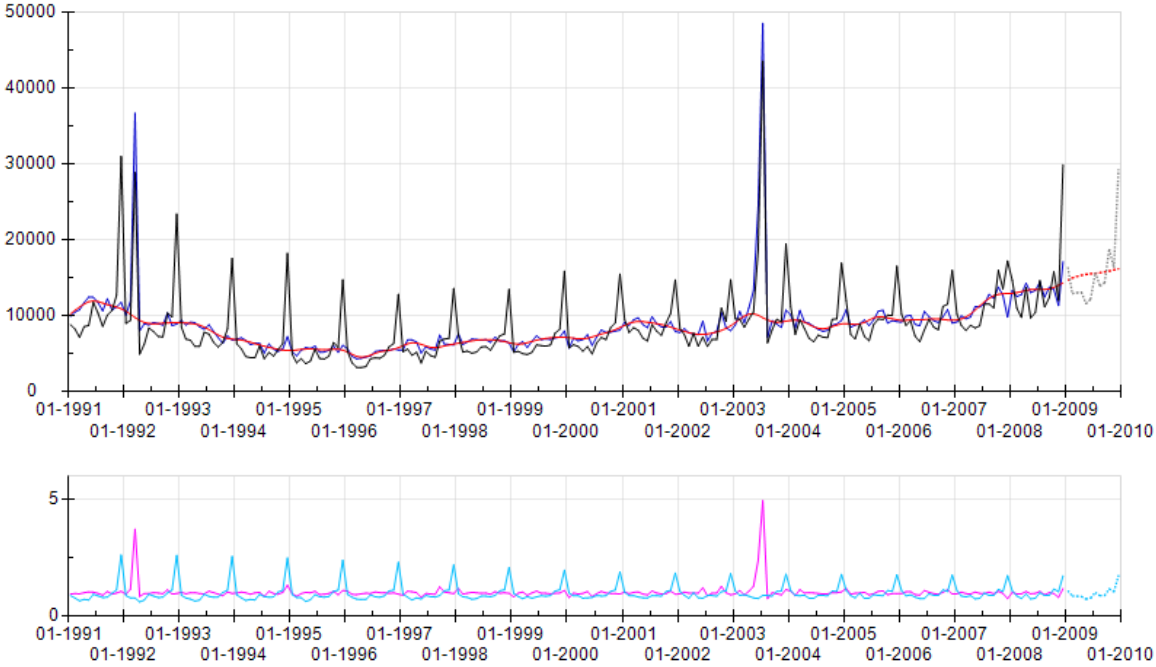
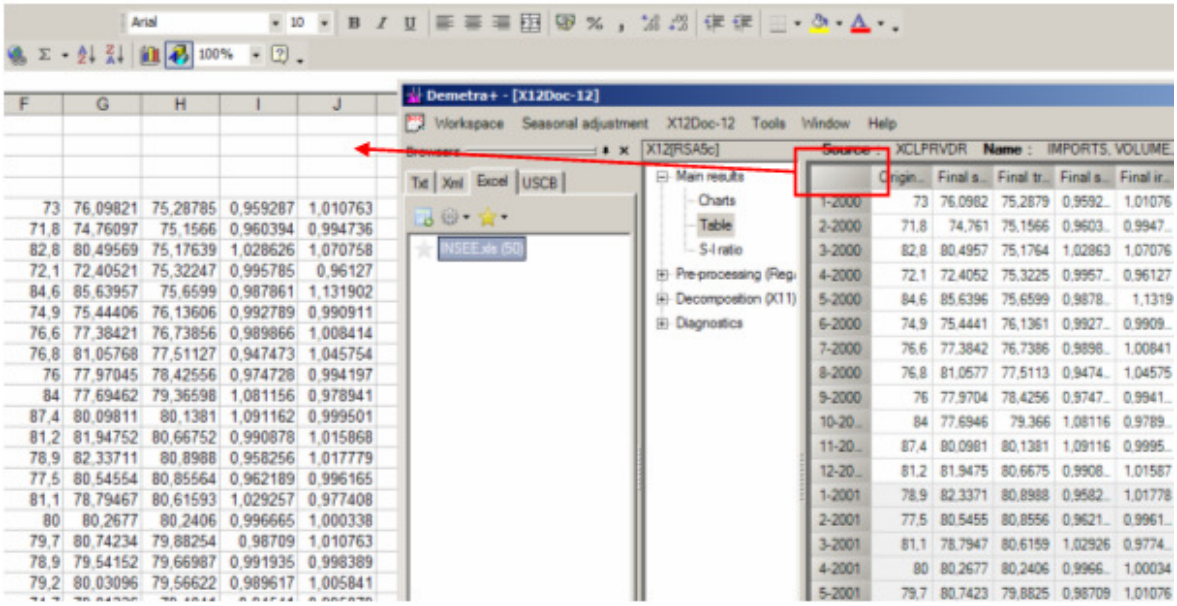


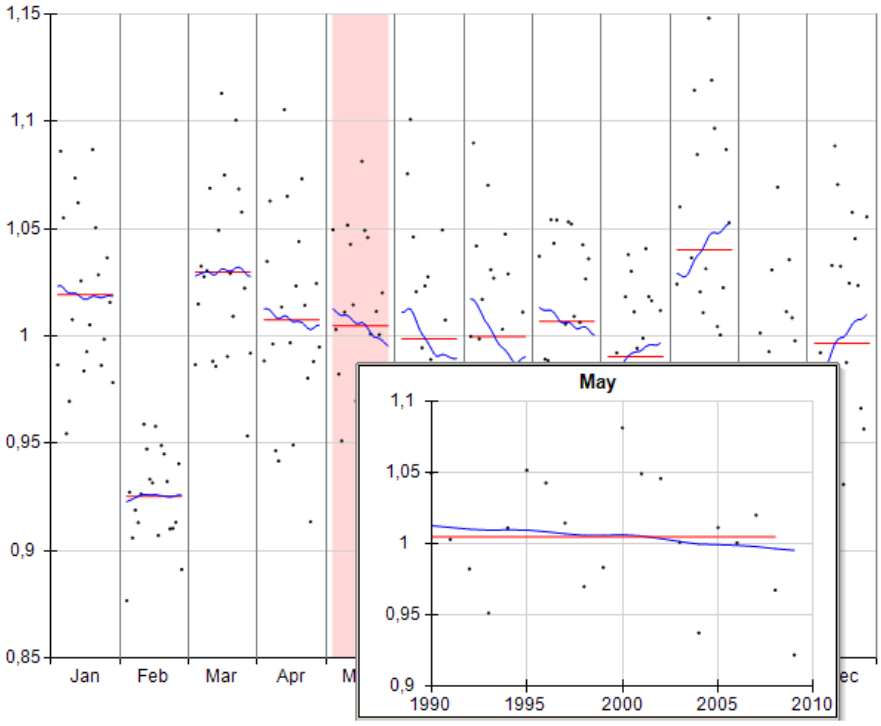
Table presents the original series with forecasts and forecast error, the final seasonally adjusted series, the final trend with forecasts, the final seasonal component with forecasts and the final irregular component in the following way:

	Original series	Final seasonally adjusted series	Final trend compone...	Final seasonal...	Final irregula...	C	Fi...	Final trend component (forec
1-1991	8826	9920,93	10273,3	0,889635	0,9657			
2-1991	8239	10504,2	10736,7	0,784352	0,978344			
3-1991	7173	10791,4	11152	0,664698	0,967662			
4-1991	8586	11744	11555	0,731099	1,01635			
5-1991	8724	12473,7	11856,5	0,699392	1,05206			
6-1991	11795	12434,4	11962	0,948577	1,0395			
7-1991	10358	11759,4	11880,8	0,880827	0,989783			
8-1991	8618	10648,2	11687,5	0,809336	0,911081			
9-1991	10104	12247,4	11483,3	0,82499	1,06654			
10-19...	10712	10784,9	11309,7	0,993241	0,953596			
11-19...	12695	11165,2	11153,9	1,13701	1,00101			
12-19...	30960	11762,6	10945,1	2,63208	1,07469			

The table can be copied to Excel by dragging and dropping the top left corner cell to excel sheet.

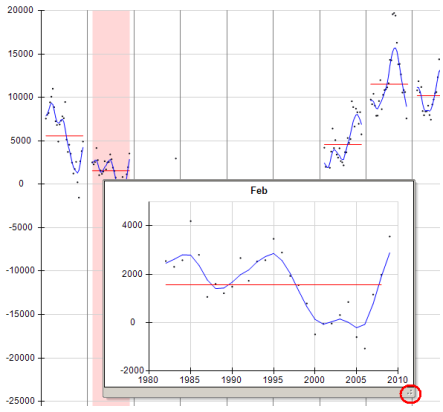


The *S-I ratio* chart presents the final estimation of the seasonal-irregular (S-I) component and final seasonal factors for each of the period in time series (months or quarters). Blue curves represent the final seasonal factors and the red straight lines represent the mean seasonal factor for each period. The S-I ratio (dots) presented on the chart is modified for extreme values. S-I ratio values come from table D9 of X12 results (see: Decomposition (X11) -> D-tables). Final seasonal factors are calculated by applying moving average to the *S-I ratio* from table D9. The results - the final seasonal factors (blue curves) - are displayed in table D10[27].



27 For more details refer to LADIRAY, D., and QUENNEVILLE, B. (1999).

You can enlarge a specific period in the *S-I ratio* chart by clicking in its zone. The details are displayed in a resizable pop-up window (drag the right bottom corner).

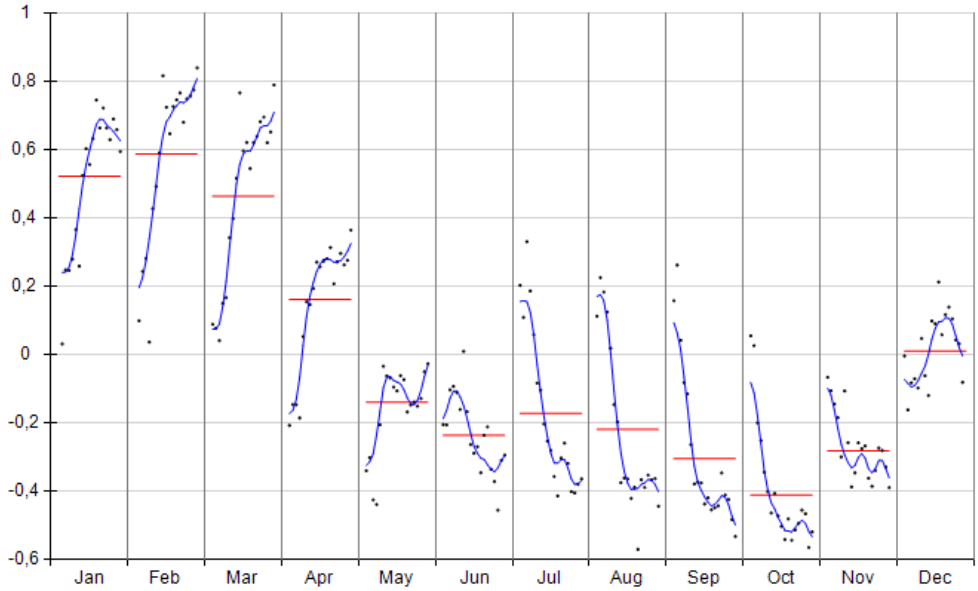


The *S-I ratio* chart is a useful diagnostic tool. This chart supports detection of seasonal breaks. These would show up as an abrupt changes to the level of the S-I ratios. A seasonal break could distort the estimation of the seasonal component and because of that it should be appropriately modeled[28].

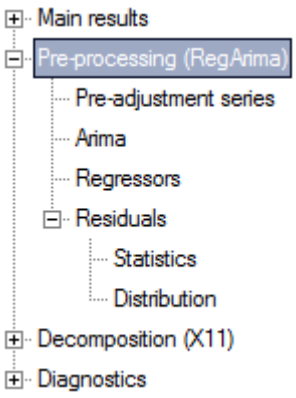
The *S-I ratio* chart also reveals the periods with more statistical variability than typical periods (i.e. typical variability for specific time series). If the *S-I ratio* seem to be very erratic, the seasonal factors will be erratic too. The seasonality is expected to be relatively stable, so in case of high variability of seasonal component the user should choose a longer moving average for its estimation.

Changes in seasonality over time are acceptable unless there is a noticeable change from below to above the overall mean (or vice versa). The overall mean is equal to 1 in case of additive model and 0 in case of multiplicative model. The problem is illustrated with the chart below. The S-I ratios for majority of periods are highly unstable. For some of them (e.g. S-I ratios for July, August, September) the effect of seasonality on time series changes from positive to negative. On the contrary, the values of the seasonal component for April indicate that for this period in the beginning of the time series the seasonally adjusted data were higher than raw series while in the end of the period the seasonally adjusted data were smaller than raw series.

28 See: 'Guide To Seasonal Adjustment' (2007).



4.3.2.1.2. Pre-processing



The first part of the pre-processing output includes information about the data. The notation of estimation span varies according to the frequencies (for example [2-1993 : 10-2006] represents monthly and [II-1994 : I-2011] represents quarterly time series), number of observations actually used in the model, number of parameters in the model, data transformation, correction for leap years) and various information criteria calculated for the model. Number of effective observations is the number of observations used to estimate the model, i.e. the number of observations of regular and seasonal differenced series. Number of estimated parameters is the sum of regular and seasonal parameters for both AR and MA, mean effect, trading/working days effect, outliers, regressors and standard error of model.

In the pre-processing part the model is estimated by exact Maximum Likelihood Estimation [29] standard error of the regression (ML estimate) is the standard error of the regression from Maximum Likelihood Estimation. Demetra+ displays a maximized value of Likelihood function after iterations processed in Exact Maximum Likelihood estimation. This value is used by model selection criteria: AIC, AICC BIC, BIC (Tramo definition) and Hannan-Quinn[30]. Those criteria are used in seasonal adjustment procedures for the selection of the proper Arima model. The model with the smaller value of the model selection criteria is preferred.

The charts below present an exemplary output.

Data transformation

Estimation span: [1-2000 : 1-2010]

Model adequation

Number of effective observations = 108
Number of estimated parameters = 11

Loglikelihood = -329,7818
Standard error of the regression (ML estimate) = 5,07962
AIC = 681,5635
AICC = 684,3135
BIC = 711,0670
BIC (Tramo definition) = 3,6840
Hannan-Quinn = 693,5261

Next the estimated model parameters, their standard errors, t-statistics and corresponding p-values are displayed. Demetra+ uses the following notation:

d: regular difference order,

D: Seasonal difference order,

Phi(p): regular AR parameter in p^{th}-order,

Th(q): regular MA parameter in q^{th} -order,

BPhi(P): seasonal AR parameter in P^{th} -order,

BTh(Q): seasonal MA parameter in Q^{th} -order.

In the example below the Arima model (0,1,0)(0,1,1) was chosen, which means that only one seasonal moving average parameter was calculated. The p-value indicates that the regressor is significant.

29 Maximum Likelihood Estimation is a parameter estimation method that determines the parameters that maximize the probability (likelihood) of the sample data.

30 AIC, AICC BIC and Hannan-Quinn criteria are used by X12 while BIC (Tramo definition) by TramoSeats. Information criteria formulas are given in the Annex.

ARIMA model [(0,1,0)(0,1,1)]

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
BTh(1)	-0,3376	0,0882	-3,83	0,0002

For fixed Arima parameters (see 4.1.3.4) Demetra+ shows only the parameters' values. From the example below it is clear that the user has chosen manually Arima model (0,1,1)(0,1,1) with fixed parameter Th(1).

ARIMA model [(0,1,1)(0,1,1)]

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
Th(1)	-0,7220			
BTh(1)	-0,8613	0,0489	-17,62	0,0000

If Arima model contains a constant term (detected automatically or introduced by the user), estimated value and related statistics are reported:

Mean effect

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
mu	-0,0007	0,0001	-6,50	0,0000

Demetra+ presents estimated values of coefficients of one or six regressors depending on the calendar effect specification's type. Joint F-test value is reported under the estimated values if six regressors specification are chosen. If a leap year regressor has been used in the model specification, estimated leap year coefficient value is also reported with its standard error, t-statistics and the corresponding p-value. If option "UserDefined" in calendar effect has been chosen, Demetra+ displays "User-defined trading days" section with variables and theirs estimation results (parameters' values, standard errors, t-statistics and corresponding p-values) and joint F-test result.

In the example below a RSA5c specification has been used and trading days effects have been detected. From the table below it can be noticed, that the regressor for Saturday influences time series in the opposite direction to the other trading days regressors. In spite of the fact that some trading days regressors are insignificant on 5% significance level, the outcome of the join F-test indicates that the trading days regressors are jointly significant.

Calendar effects

Trading days

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
Monday	1,56913	0,658382	2,38	0,0191
Tuesday	-2,00054	0,649465	-3,08	0,0027
Wednesday	1,47783	0,678829	2,18	0,0319
Thursday	0,581356	0,659519	0,88	0,3802
Friday	0,250291	0,632428	0,40	0,6931
Saturday	-0,829103	0,628534	-1,32	0,1902
Sunday (derived)	*-1,04896*	*0,659838*	*-1,59*	*0,1151*

Join F-Test on trading days: F = 4,1350 [P-Value = 0,0010]

If Easter effect was estimated, the following table will be displayed in the output. It is clear, that in the case presented below, Easter has a positive, significant effect on the time series (on 1% level).

Easter

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
easter [15]	4,45711	1,30909	3,40	0,0009

The p-value suggests that leap year effect is insignificant.

Leap year

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
leap year	0,331051	2,03402	0,16	0,8710

Demetra+ presents also the results of outliers' detection. The table includes the type of outlier, its time point/date, parameter's value and significance.

Detected outliers

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
AO[4-2002]	18,7046	3,41647	5,47	0,0000
LS[1-2007]	38,5629	4,60194	8,38	0,0000

If the user adds a ramp regressor to the model specification, range of ramp variable, estimated value of coefficient and related statistics are shown in appropriate section.

Ramps

Parameter	*Value*	*Std error*	*T-Stat*	*P-value*
rp:2010-05-30-2010-06-30	-0,0104	0.0121	-0,86	0,3908

If a user adds an intervention variable to the model specification, estimated value of coefficient and related statistics are shown under "Intervention Variables".

Pre-adjustment series

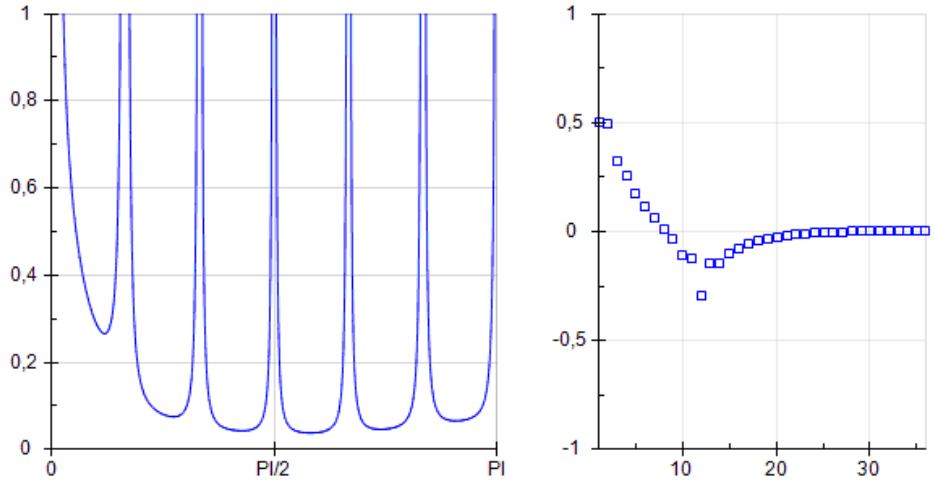
The table presented in this section contains series estimated by RegArima part. The contents of the table depend on the effects estimated by RegArima. The following items can appear here:

- **Interpolated series** – series interpolated for the missing observations (if any),
- **Linearized series** – all deterministic effect-adjusted series,
- **Series corrected for the calendar effect** – series corrected for all calendar effects (also user-defined variables assigned to calendar component),
- **Deterministic component** – all deterministic effects such as outliers, ramps, calendars etc.,
- **Calendar effect** – total calendar effect, i.e. joint effect of moving holidays, trading day and Easter effects,
- **Moving holidays effect** – the same (provisionally) as **Easter effect**,
- **Trading day effect** – automatically detected or user-entered trading-day effects, i.e. pre-defined, user-calendar and user-define regressors in calendar module,
- **Easter effect** – automatically detected or user-entered Easter effect**,**
- **Outliers effect on the irregular component** – additive and transitory change outliers,
- **Outliers effect on the trend component** – level shift effects,
- **Total outliers effect** – the sum of the outliers effects on trend and irregular components,
- **Separate regression effect** – user-defined variable effect assigned to none of components,
- **Regression effect on the trend component** – ramps, intervention variables for which Delta≠0 and DeltaS=0 and user-defined variable effects assigned to trend,
- **Regression effect on the seasonal component** – intervention variables for which DeltaS≠0[31] and user-defined variable assigned to holiday,
- **Regression effect on the irregular component** – user-defined variables effects assigned to irregular,
- **Regression effect on the seasonally adjusted series** – the sum of the regression effects on the trend and irregular components, and separate regression effects,
- **Total regression effect** – the sum of the regression effects on the trend, seasonal and irregular components, and separate regression effects**.**

31 If both Delta≠0 and DeltaS≠0, intervention variable automatically assigns to seasonal component.

Arima

This section consists of three parts. It demonstrates a theoretical spectrum of the stationary and non-stationary model and autocorrelation function of the stationary part of the model. In the top-left part, an infinite sample spectrum graphic is displayed. The blue line represents the Arima model identified by regArima. In the top-right part, an auto-correlation graph corresponding to the Arima model is presented. In the bottom part, estimated coefficients of parameters (regular and seasonal AR and MA) are shown in closed form (i.e. using the backshift operator B). In this part frequencies corresponding to regular AR parameters are also reported (if they are present).



Polynomials

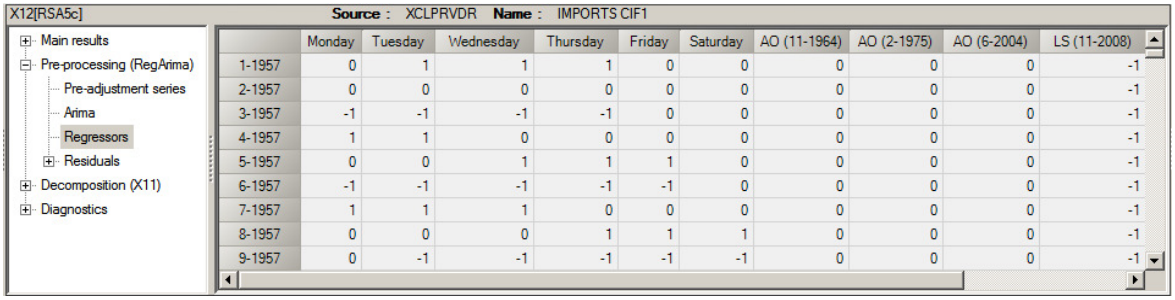
regular AR: 1 - 0,34299 B - 0,32833 B^2
seasonal AR: 1
regular MA: 1
seasonal MA: 1 - 0,35933 S

Frequency of the regular AR roots

3,14159265358979

Regressors

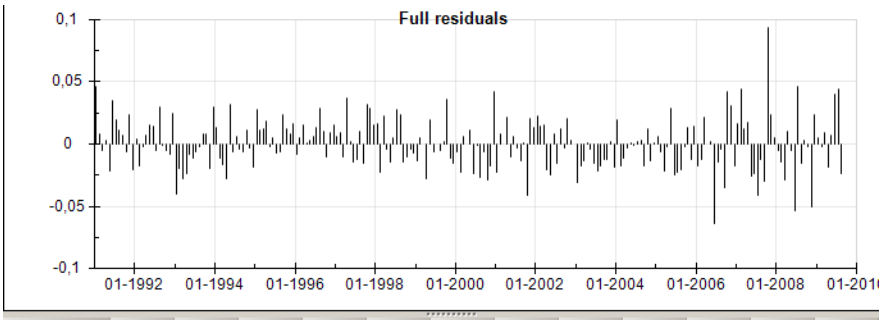
This section presents all deterministic regressors used by RegArima part, including trading days variables, leap year effect, outliers, Easter effect, ramps, intervention variables, user-defined variables.



	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	AO (11-1964)	AO (2-1975)	AO (6-2004)	LS (11-2008)
1-1957	0	1	1	1	0	0	0	0	0	-1
2-1957	0	0	0	0	0	0	0	0	0	-1
3-1957	-1	-1	-1	-1	0	0	0	0	0	-1
4-1957	1	1	0	0	0	0	0	0	0	-1
5-1957	0	0	1	1	1	0	0	0	0	-1
6-1957	-1	-1	-1	-1	-1	0	0	0	0	-1
7-1957	1	1	1	0	0	0	0	0	0	-1
8-1957	0	0	0	1	1	1	0	0	0	-1
9-1957	0	-1	-1	-1	-1	-1	0	0	0	-1

Residuals

The way in which Demetra+ calculates the residuals is presented in the Annex (section 1A). Residuals from the model are presented in the graph and in the table.



	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1991	0,046	0,009	-0,005	0,004	-0,022	0,035	0,019	0,012	0,007	-0,006	0,024	-0,020
1992	0,004	-0,018	-0,002	0,007	0,016	0,014	-0,005	0,030	-0,001	-0,005	-0,008	0,024
1993	-0,040	-0,020	-0,028	-0,024	-0,008	-0,011	-0,006	-0,002	0,008	0,008	-0,020	0,029
1994	0,014	-0,012	-0,016	-0,028	0,031	-0,006	0,006	-0,005	-0,007	0,012	-0,004	-0,019
1995	0,028	0,011	0,012	0,018	-0,002	0,005	-0,007	-0,006	0,023	0,012	0,009	0,016
1996	-0,009	0,005	0,015	0,002	0,003	0,006	0,014	0,029	0,011	-0,010	0,009	0,015
1997	0,007	0,009	-0,010	0,037	0,002	-0,014	-0,012	0,011	-0,016	0,031	0,029	0,015
1998	0,017	-0,023	0,022	-0,004	-0,015	0,005	0,028	0,024	-0,015	-0,011	-0,004	-0,007
1999	-0,013	0,005	0,000	-0,028	0,019	-0,006	0,000	-0,005	0,002	0,036	-0,012	-0,016
2000	-0,006	-0,022	0,006	0,000	0,012	-0,024	-0,001	-0,027	-0,007	-0,029	-0,018	0,042
2001	-0,023	0,008	0,000	0,021	-0,011	0,006	-0,003	-0,013	0,001	-0,042	0,021	0,013

Analysis of the residuals consists of several tests, which are described in the Annex (section 12A). Summary statistics are presented in the following tables:

1. Normality of the residuals

	P-value
Mean	0,2032
Skewness	0,2986
Kurtosis	0,6680
Normality	0,4859

2. Independence of the residuals

	P-value
Ljung-Box(24)	0,5164
Box-Pierce(24)	0,5781
Ljung-Box on seasonality(3)	0,4087
Box-Pierce on seasonality(3)	0,4442

3. Randomness of the residuals

	P-value
Runs around the mean: number	0,8312
Runs around the mean: length	1,0000
Up and Down runs: number	0,7453
Up and Down runs: length	1,0000

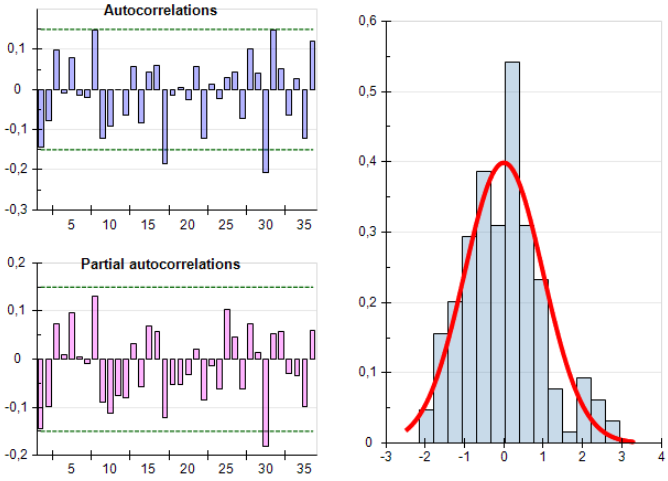
4. Linearity of the residuals

	P-value
Ljung-Box on squared residuals(24)	0,0028
Box-Pierce on squared residuals(24)	0,0054

For each test, corresponding p-value is reported. The p-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed. Green p-value means "Good", yellow means "Uncertain" and red means "Bad". In the example above, for tests one to three the null hypothesis was accepted (p-values higher than 5%). It means that it can be assumed that residuals are independent and random. They are approximately normally distributed.

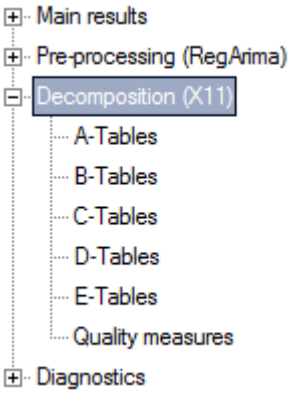
The p-value marked in red indicates that the null hypothesis was rejected. *Linearity of the residuals* test provides an evidence of autocorrelation in residuals. A linear structure is left in the residuals.

Demetra+ also presents a distribution of the residuals. In this section autocorrelation and partial autocorrelation functions as well as histogram graphics of residuals estimated from RegArima model are presented.



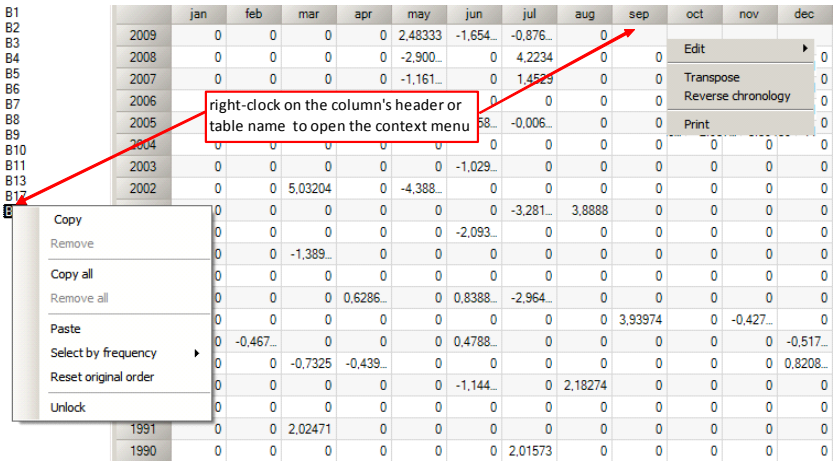
4.3.2.1.3. Decomposition

This part includes tables with results from consecutive iterations of X-11 algorithm and quality measures.



Tables

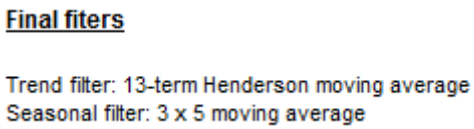
In this section key tables from the X-11 procedure are available. Some tables produced by the original X-11 algorithm are omitted. As an example the view of B20 table is presented below:



A detailed list of the tables can be found in the Annex (section 8A).

Quality measures

This section presents the seasonal and trend moving filters used to estimate the seasonal factors and the final trend-cycle. Demetra+ selects the filters automatically, taking into account the global moving seasonality ratio, which is computed on preliminary estimates of the irregular component and of the seasonal.



Relative contribution of the components to the stationary portion of the variance in the original series

I	C	S	P	TD&H	Total
3,36	21,83	25,48	38,05	1,81	90,53

The M statistics are used to asses the quality of seasonal adjustment[32]. These statistics vary between 0 and 3 but only values smaller than 1 are acceptable. M1 measures the contribution of the irregular component to the total variance. M2, which is very similar to M1, is calculated on the basis of the contribution of the irregular component to the stationary portion of the variance. Statistic M3 compares the irregular to the trend-cycle taken from a preliminary estimate of the seasonally adjusted series, because if this ratio is too large, it is difficult to separate the two components from each other. Statistic M4 tests the randomness of the irregular component. The statistic M5 is used to compare the significance of changes in trend with that in the irregular. Statistic M6 checks the S-I (seasonal - irregular component ratio) because if annual changes in the irregular component are too small in relation to the annual changes in the seasonal component, the 3×5 seasonal filter used for the estimation of the seasonal component is not flexible enough to follow the seasonal movement. It should be underlined that statistic M6 is calculated only if this filter has been applied in the model. Statistic M7 is the combined test for the presence of identifiable seasonality. The test compares the relative contribution of stable and moving seasonality[33]. Statistics M8 to M11 measure if the movement due to short-term quasi-random variations and movement due to long term changes are not changing too much over the years. If the changes are too strong then the seasonal factors could be erroneous.

Q statistic is a composite indicator calculated from M statistics.

$$Q=\frac{10M1+11M2+10M3+8M4+11M5+10M6+18M7+7M8+7M9+4M10+4M11}{100}$$

Q without M2 (also called Q2) is the Q statistic without the M2 statistics. If time series does not cover at least 6 years statistics M8, M9, M10 and M11 cannot be calculated. In this case the Q statistics is computed as:

$$Q=\frac{14M1+15M2+10M3+8M4+11M5+10M6+32M7+0M8+0M9+0M10+0M11}{100}$$

The model has a satisfactory quality if Q statistic is less than 1.

Results of the test

Treshold	***Diagnostic***
≥2	Severe
[1,2[	Bad
<1	Good

32 For the definitions of the M statistics see LADIRAY D., and QUENNEVILLE B. (1999).

33 See the Annex (section 12A).

Monitoring and Quality Assessment Statistics

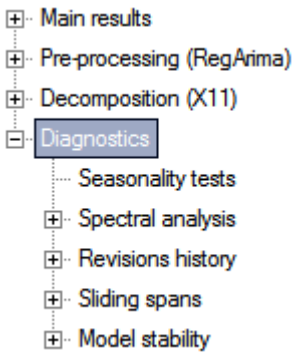
Measure	Value
M1	0,801
M2	0,543
M3	1,003
M4	0,080
M5	0,800
M6	0,728
M7	0,393
M8	0,550
M9	0,333
M10	0,567
M11	0,000

Summary

Q	0,584
Q without M2	0,589

4.3.2.1.4. Diagnostics

The *Diagnostic* panel contains detailed information on the seasonal adjustment process.



Main results

Main results are presented in the first chart.

A description of tests presented in the *Diagnostic* panel is presented below.

- ## Basic checks

The first section includes two quality diagnostics: *definition* and *annual totals*.

- ### Definition

This test is inspecting some basic relationships between different components of the time series. The following components are used in formulas that are tested[34]:

Name	***Code***	***Definition***
Y	y(_f)	Original series
Yc	yc(_f)	Interpolated series (= Y with missing values relaced by their estimates)
T	tl(_f)	Trend (without regression effects)
S	sl(_f)	Seasonal (without regression effects)
I	il	Irregular (without regression effects)

34 The names mentioned in the document appear in the graphical interface of Demetra+. The corresponding codes are used in the csv output. For compatibility issues with previous versions, they have not been aligned on the names. For some series, it is possible to generate the forecasts (computed on 1 year); the corresponding code is defined by adding the "_f" suffix (for example, y becomes y_f).

SA	sal	Seasonally adjusted series(without regression effects)
SI		S-I ratio
TDE	td(_f)	Trading days effects
MHE	mh(_f)	Moving holidays effects
EE		Easter effects
RMDE		Ramadan effects
OMHE		Other moving holidays effects
CAL	cal(_f)	Calendar effects
OTOT O(cmp=T,S,I)	out out_t, out_s, out_i	Outliers effects
REGTOT REG(cmp=Y, SA, T,S, I)	reg(_f) reg_y(_f), reg_sa(_f) reg_t(_t), reg_s(_f), reg_i(_f)	Other regression effects
DET(cmp=T,S, I,Y)	det(_f) det_y(_f), det_sa(_f) det_t(_f), det_s(_f), det_i(_f)	Deterministic effects
C(cmp=T,S,I,SA)	t(_f), s(_f), i, sa	Components, including deterministic effects
Ycal	ycal	Calendar adjusted series
Yl	yl	Linearized series

For those components in additive case the following relationships should be true:

$$MHE = EE + RMDE + OMHE \quad (1)$$

$$CAL = TDE + MHE \quad (2)$$

$$OTOT = OT + OS + OI \quad (3)$$

$$REGTOT = REGT + REGS + REGI + REGY \quad (4)$$

$$REGSA = REGT + REGI \quad (4)$$

$$DET = CAL + OTOT + REGTOT \quad (5)$$

$$CT = T + OT + REGT \quad (6)$$

$$CS = S + CAL + OS + REGS \quad (7)$$

$$CI = I + OI + REGI \quad (8)$$

$$CSA = Y_c - CS = CT + CI + REGY \quad (9)$$

$$Y_c = CT + CS + CI + REGY = T + S + I + DET \quad (10)$$

$$Y_l = Y_c - DET = T + S + I \quad (11)$$

$$SA = Y_l - S = T + I \quad (12)$$

$$S_l = Y_l - T = S + I \quad (13)$$

A multiplicative model is obtained in the same way by replacing the operations "+" and "-" by "*" and "/" respectively.

The *Definition* test verifies that all the definition constraints are well respected. The maximum of the absolute differences is computed for the different equations and related to the Euclidean norm of the initial series (Q).

Results of the test

Q	***Diagnostic***
> 0.000001	**Error**
<= 0.000001	Good

- **Annual totals**

The test compares the annual totals of the original series and those of the seasonally adjusted series. The maximum of their absolute differences is computed and related to the Euclidean norm of the initial series.

Results of the test

Q	***Diagnostic***
> 0.5	Error
]0.1, 0.5]	Severe
]0.05, 0.1]	Bad
]0.01, 0.05]	Uncertain
<=0.01	Good

• Visual spectral analysis

Demetra+ identifies spectral peaks in seasonal ad trading days components using an empirical criterion of "visual significance". For more information see the Annex (section 9A).

• RegArima Residuals diagnostics

Several tests are computed on the residuals of the RegArima model. The exact definition of what we mean by "residuals" should be clarified. Indeed, X12 and Tramo are based on different estimation procedures of the likelihood of the RegArima models, which lead to different residuals. Demetra+ takes another way (similar to the solution developed in Stamp, for instance). The Annex (section 1A) describes those solutions.

In most cases, the different sets of residuals yield slightly different diagnostics. However, their global messages are nearly always very similar[35].

- **Normality test**

The joint normality test (which combines skewness and kurtosis tests) is the Doornik-Hansen test (see the Annex, section 12A), which is distributed as a χ^2.

Results of the test

Pr(χ^2 >val)	***Demetra+ default setting***
<0.01	Bad
[0.01, 0.1[	Uncertain
≥0.1	Good

- **Independence test**

The independence test is the Ljung-Box test (see the Annex, section 12A), which is distributed as $\chi^2(k-np)$,where k depends on the frequency of the series (24 for monthly series, 8 for quarterly series, $4*freq$ for other frequencies, where $freq$ is a frequency of the time series) and np is the number of hyper-parameters of the model (number of parameters in the Arima model).

Results of the test

Pr($\chi^2(k-np)$ >val)	***Demetra+ default setting***
<0.01	Bad
[0.01, 0.1[	Uncertain
≥0.1	Good

- **Spectral test**

Demetra+ checks the presence of the trading days and seasonal peaks in the residuals using the test based on the periodogram of the residuals. The periodogram is computed at the so-called Fourier frequencies. Under the hypothesis of Gaussian white noise of the residual, it is possible to

35 In future versions of Demetra+, it will be possible to choose the definition of the residuals that must be used in the tests and displayed in the graphical interface. Obviously, the choice is more a question for purists.

derive simple test on the periodogram, around specific (groups of) frequencies. The exact definition of the test is described in the Annex (section 12A).

Results of the test

P(stat>val)	*Demetra+ default setting*
<0.001	Severe
[0.001, 0.01[	Bad
[0.01, 0.1[	Uncertain
≥0.1	Good

- **Residual seasonality diagnostics**

The residual seasonality diagnostics implemented in Demetra+ correspond to the set of tests developed in X12. One of them is F-test on stable seasonality (see the Annex, section 12A), which is computed on the differences of the seasonally adjusted series (component CSA, see above) and on the irregular component (component CI, see above).

In order to extract the trend from the monthly time series a first order difference of lag three is applied (a first order difference of lag one in the other cases)[36]. For the seasonally adjusted series, it is tested if residual seasonality is present. Test is performed twice: on the complete time span and on the last 3 years span.

Results of the test

Pr(F>val)	*Demetra+ default setting*
<0.01	Severe
[0.01, 0.05[	Bad
[0.05, 0.1[	Uncertain
≥0.1	Good

- **Number of outliers**

A high number of outliers indicates that there is a problem related to a weak stability of the process or the reliability of the data is low. If the high number of outliers has been detected (above 3%, according to the table), the chosen Arima model cannot fit all of the observations.

Results of the test

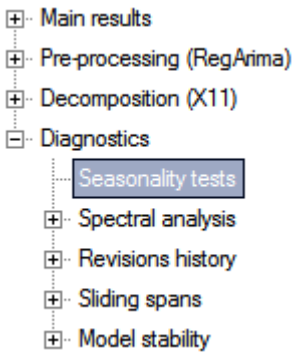
Treshold	*Demetra+ default setting*
≥0.1	Severe
[0.05, 0.1[	Bad
[0.03, 0.05[	Uncertain
<0.3	Good

36 DAGUM, E. B. (1987).

- **M-statistics**

For the test results refer to 4.3.2.1.3.

Seasonality tests



The diagnostic node includes the set of seasonality tests useful for checking the presence of seasonality in time series. Those tests are described in the Annex (section 12A). The exemplary results from Demetra+ are discussed below. All tests have been calculated for the same time series.

- **Friedman test**

The seasonal component includes the intra-year variation that is repeated each year (stable seasonality) or evolving from year to year (moving seasonality). To determine if stable seasonality is present in a series Demetra+ computes the Friedman test using the seasons (months or quarters) as the factors on the preliminary estimation of the unmodified S-I component.

Friedman test

Friedman statistic = 73,4321
Distribution: F-stat with 11 degrees of freedom in the numerator and 154 degrees of freedom in the denominator
P-Value: 0,0000
Stable seasonality present at the 1 per cent level

A high test statistics and low significance level indicates that a significant amount of variation in the S-I ratios is due to months (or quarters, respectively), which in turn is evidence of seasonality. If the p-value is lower than 0.1% the null hypothesis of no seasonal effect is rejected. Conversely, a small value of the F-test and high significance level (close to 1.0) is evidence that variation due to month or quarter could be due random error and the null hypothesis of no month/quarter effect is not rejected37.

37 http://support.sas.com/onlinedoc/913.

In the example above p-value is 0.0000, so the null hypothesis is rejected and it could be assumed that seasonality is present.

- **Kruskal-Wallis test**

The second test for stable seasonality provided by Demetra+ is the Kruskal-Wallis test.

Kruskall-Wallis test

Kruskall-Wallis statistic = 162,5477
Distribution: Chi2(11)
P-Value: 0,0000
Stable seasonality present at the 1 per cent level

In the example above the outcome of the test is stable seasonality present. This outcome confirms the result from Friedman test.

- **Test for the presence of seasonality assuming stability**

Test for the presence of seasonality assuming stability uses the following decomposition of the variance: $S^2 = S_A^2 + S_R^2$

where:

$S^2 = \sum_{j=1}^{k}\sum_{i=1}^{n_j}(X_{ij} - \bar{X})^2$ – the total sum of squares,

$S_A^2 = \sum_{j=1}^{k} n_j(\bar{X}_{\bullet j} - \bar{X}_{\bullet\bullet})^2$ – variance of the averages, due to seasonality,

$S_R^2 = \sum_{j=1}^{k}\sum_{i=1}^{n_j}(X_{ij} - \bar{X}_{\bullet j})^2$ – the residual sum of squares.

The test statistics is calculated as:

$$F_S = \frac{\frac{S_A^2}{k-1}}{\frac{S_R^2}{n-k}} \sim F(k-1, n-k)$$

where $k-1$ and $n-k$ are degrees of freedom.

The example is shown below:

Test for the presence of seasonality assuming stability

	Sum of squares	degrees of freedom	Mean square
Between months	0,3532	11	0,0321
Residual	0,0544	179	0,0003
Total	0,4075	190	0,0021

Value: 105,6788
Distribution: F-stat with 11 degrees of freedom in the numerator and 179 degrees of freedom in the denominator
P-Value: 0,0000
Seasonality present at the 1 per cent level

The test statistic was calculated in the following way:

$$F_S = \frac{\frac{0,3532}{12-1}}{\frac{0,0544}{191-12}} \sim F(11,179)$$

The p-value is $0,0000$ so the null hypothesis is rejected and it could be assumed that the seasonality in time series is significant.

- **Evolutive seasonality test**

The test verifies if seasonality is stable over years. The test value placed below indicates no evidence of moving seasonality on 20 per cent level.

Evolutive seasonality test

	Sum of squares	Degrees of freedom	Mean square
Between years	0,0021	14	0,0001
Error	0,0305	154	0,0002

Value: 0,7419
Distribution: F-stat with 14 degrees of freedom in the numerator and 154 degrees of freedom in the denominator
P-Value: 0,7296
No evidence of moving seasonality at the 20 per cent level

The test value was computed in a following way[38]:

$$F_M = \frac{\frac{0,0021}{14}}{\frac{0,0305}{154}} = 0,76.$$

38 Because sum of squares displayed by Demetra+ are rounded rather than exact, the result of computation made by the user is not the same as one obtained by Demetra+.

- **Combined seasonality test**

Combined seasonality test uses Kruskal-Wallis test, test for the presence of seasonality assuming stability, evaluative seasonality test and test for presence of identifiable seasonality in procedure that tests whether the seasonality of the series is identifiable. For the time series analyzed in this section combined seasonality test seasonality has been identified.

Combined seasonality test

Identifiable seasonality present

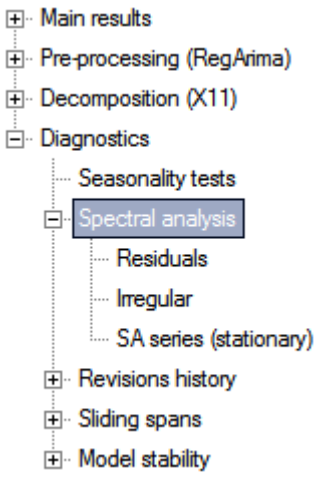
- **Residual seasonality test**

Residual seasonality test is F-test computed on seasonally adjusted series on the complete time span and on the last 3 years span. Demetra+ displays here F-statistics and conclusion drowned from them (*No evidence of residual seasonality…*). P-values calculated for this test are given in Diagnostic ->Residual seasonality diagnostics part**.**

Residual seasonality test

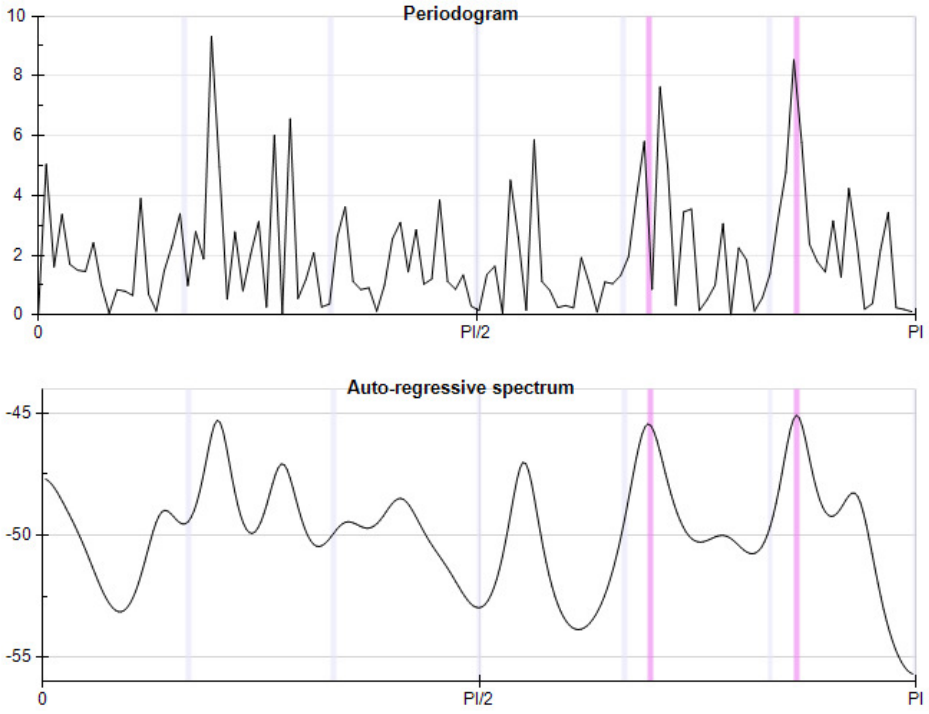
No evidence of residual seasonality in the entire series at the 10 per cent level: F=0,2132
No evidence of residual seasonality in the last 3 years at the 10 per cent level: F=0,3454

Spectral analysis



Demetra+ provides spectral plots to alert to the presence of remaining seasonal and trading day effects in seasonally adjusted time series. The graphics are available for residuals, irregular component and seasonally adjusted time series. In order to compare the results with spectral analysis for raw time series, the user should create the relevant graph for raw time series from the Tools menu (see: Chapter 3.2).

Two spectrum estimators are implemented: periodogram and auto-regressive spectrum[39]. Seasonal frequencies are marked as grey, vertical lines, while violet lines correspond to trading-days frequencies. The X-axis shows the different frequencies. The periodicity of phenomenon at frequency f is $\frac{2\pi}{f}$. It means that for monthly time series the seasonal frequencies are: $\frac{\pi}{6},\frac{\pi}{3},\frac{\pi}{2},\frac{2\pi}{3},\frac{5\pi}{6}$ (which are equivalent to $1, 2,...$ cycles per month, i.e. in the case of a monthly series, the frequency $\frac{\pi}{3}$ corresponds to a periodicity of 6 months (2 cycles per year are completed)). For the quarterly series there are two seasonal frequencies: $\frac{\pi}{2}$ (one cycle per year) and π (two cycles per year). Peak at the zero frequency always corresponds to the trend component of the series. For more detail about spectral analysis refer to the Annex (section 9A).

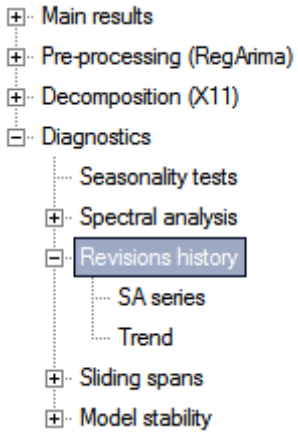


At seasonal and trading days frequencies, a peak in the residuals indicates the need for a better fitting model. In particular, peaks at the seasonal frequencies are caused by inadequate filters chosen for decomposition. Peaks at the trading days frequencies could occur due to inappropriate regression variables used in the model or the significant change of the calendar effect because the calendar effect cannot be modeled by fixed regression effect on the whole time series span.

A peak in the spectrum of the seasonally adjusted series or irregulars reveals inadequacy of the seasonal adjustment filters for the time interval used for spectrum estimation. In this case different model specification or data span length should be considered.

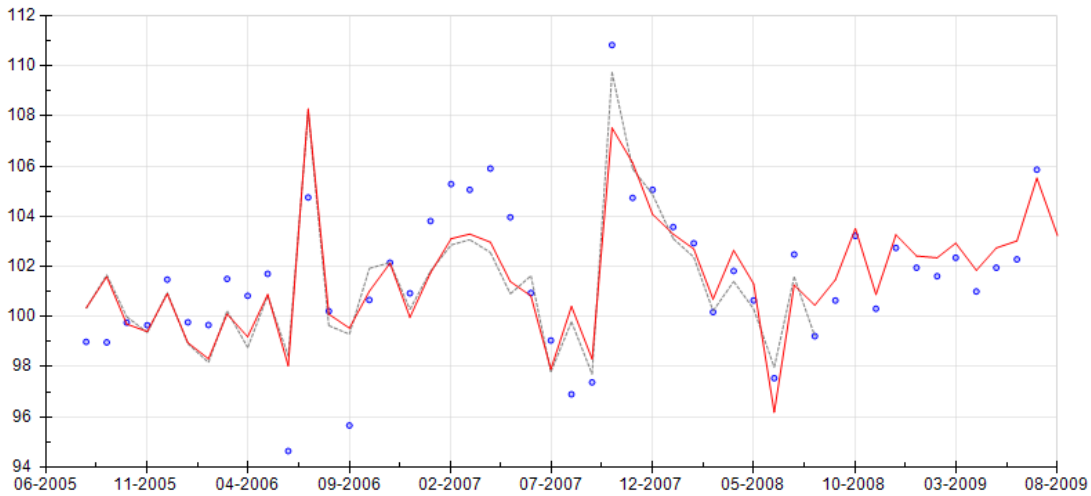
39 The theoretical motivation for the choice of spectral estimator is provided by SOKUP, R. J., and FINDLEY, D. F. (1999).

Revision histories



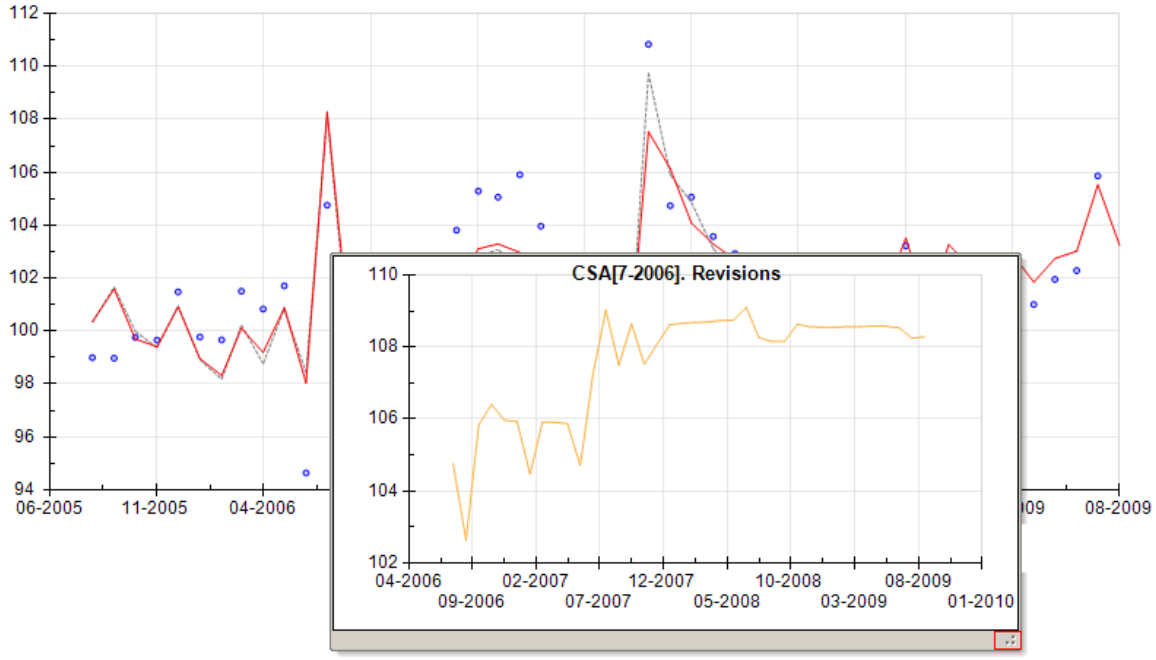
It is known, that the estimated SA and trend figures change as new observations are added to the end of the original time series. The change in the estimated SA and trend values is called revision. Revision history illustrates the changes in the seasonally adjusted series and trend series which take place as new observations are added to the end of the original time series. The illustrated difference is between the initial estimate (marked by a blue circle) and the latest estimate (red line). The difference between those two values is called a revision. As a rule, smaller revisions are better. The revision history is useful for comparing results from competing models. When the user defines two seasonal adjustment models for one time series and both these models are acceptable and then revision history can be used for choosing the better model in terms of revisions.

More detailed description is available in the Annex (section 10A).



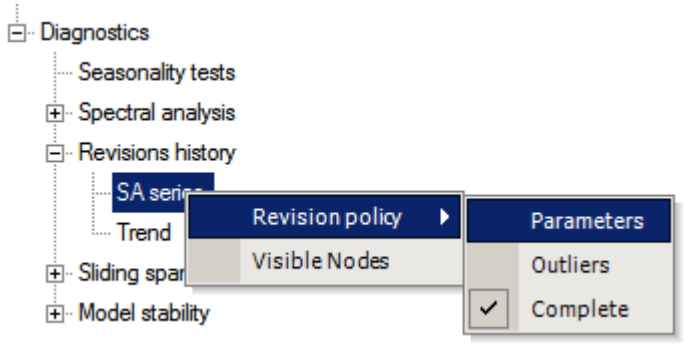
If the user clicks on a blue circle which represents the initial estimation for period t_n, an auxiliary window will appear. The figure shows the successive estimations (computed on $[t_0,...,t_n]$, $[t_0,...,t_{n+1}]$... $[t_0,...,t_T]$) of the considered series for the period t_n. From this figure the user can

evaluate how the seasonally adjusted observations have been changing from initial to final estimation. The analogous graph is available for trend analysis.

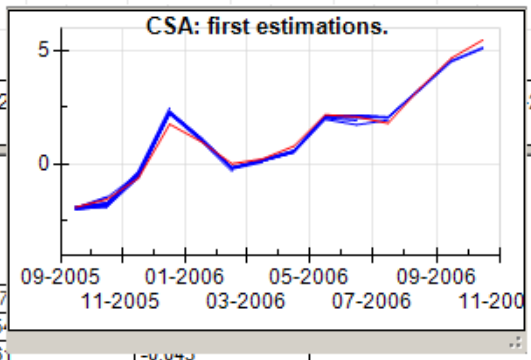


The user could establish the size of the revision using the vertical axis. In the figure above the revisions are about 5%. The figure size could be enlarged by dragging the bottom-right corner.

By default only the parameters of the model are re-estimated. It is also possible to make a complete re-estimation or a re-identification of the outliers. That option can be changed through the local menu of the revision history node (left panel), at the expense of the speed of the processing and for results that are usually very similar.



In the revisions history panels a complete overview of the different revisions for a given time span can be obtained by selecting with the mouse (just like for zooming) the considered periods. The successive estimations are displayed in a separate pop-up window.

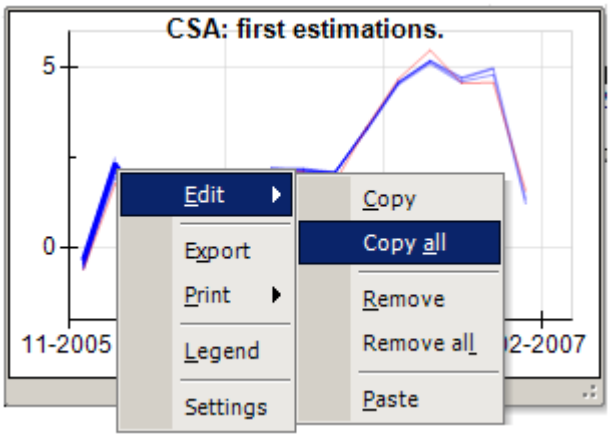


Absolute differences

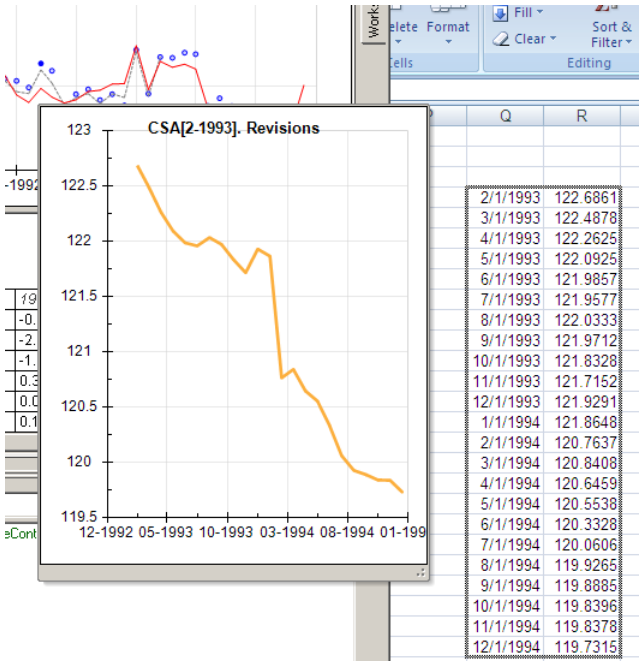
mean = -0,0061
rmse = 0,2374

	2005	*2006*	*2007*	
January	-0,186	-0,162	0,354	
February	0,163	0,340	0,061	
March	-0,098	0,141	-0,100	-0,143
April	0,079	0,262	0,064	0,216
May	0,097	0,121	-0,164	0,346
June	-0,158	0,165	0,027	0,326
July	-0,130	-0,142	-0,752	-0,357
August	-0,106	0,015	0,222	0,012
September	0,008	0,077	0,195	-0,024
October	-0,117	0,321	0,277	0,105
November	-0,186	-0,009	0,007	-0,028
December	-0,720	-0,408	-0,305	-0,011

Standard copy/print/export options are avaiable for this chart.



One can also get all the revisions for a specific period by clicking on the point that corresponds to the first estimate for that period. The results of those pop-up windows can be copied or dragged and dropped to other software (e.g. Excel).



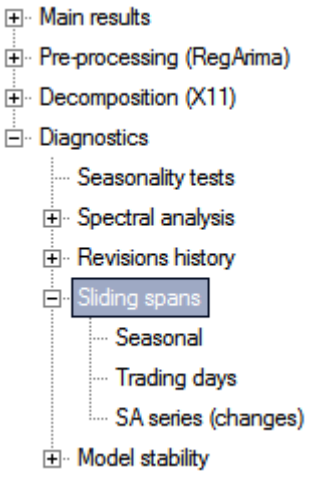
The history analysis plot is accompanied by information about the relative difference between initial and final estimation for the last four years. For the additive decomposition absolute revisions are used, for multiplicative decomposition relative differences are considered. Values which absolute value are larger (in absolute term) than 2 times the root mean squared error of the (absolute or relative) revisions are marked in red and provide information about the instability of the outcome. Information about mean relative difference between initial and final estimation over period displayed in table is also provided. As relative difference can be positive as well as negative, mean value is not very informative. Magnitude of varying revisions is measured by root mean square error (RMSE). RMSE has the same units as the mean.

Relative differences

mean = 0,0679
rmse = 1,5881

	2005	*2006*	*2007*	*2008*	*2009*
January		-0,818	-1,986	-0,272	0,460
February		-1,354	-2,070	-0,220	0,724
March		-1,383	-1,680	0,516	0,567
April		-1,622	-2,772	0,807	0,833
May		-0,810	-2,465	0,660	0,775
June		3,596	-0,118	-1,393	0,718
July		3,366	-1,159	-1,190	-0,320
August	1,367	-0,122	3,615	1,244	
September	2,640	4,056	0,959	0,822	
October	-0,060	0,346	-2,984	0,282	
November	-0,252	-0,020	1,335	0,566	
December	-0,559	-0,946	-0,932	0,509	

Sliding spans



It is expected that seasonally adjusted data are stable, which means that removing or adding data points at either end of the series does not change the SA results very much. The sliding spans analysis checks the stability of seasonal adjustment outcome. It is also used to detect the timing significant changes in the time original time series. Such changes include seasonal brakes and large number of outliers and fast moving seasonality. The sliding spans analysis is particularly useful in case of seasonal brakes[40], large number of outliers and fast moving seasonality[41].

A span is a range of data between two dates. The sliding spans are series of two, three or four (depending on the length of the original time series, seasonal moving averages used (only for X12 method) and series' frequency) overlapping spans. The program sets up a maximum of 4 spans. The spans start in 1 year intervals. The sliding spans analysis stands for the comparison of the correlated seasonal adjustments of a given observation obtained by applying the adjustment procedure to a sequence of three or four overlapping spans of data, all of which contain this observation[42]. Each period (month or quarter) that is common to more than one span is examined to see if its seasonal adjustments or some related quantities vary more than a specified amount across the spans.

---

40 A seasonal break is defined as a sudden and sustained change in the seasonal pattern of a series. The presence of this event is reflected in SI ratio. A seasonal brakes are unwanted feature of time series as the moving averages used by X12 are designed to deal with series which have a smoothly evolving 'deterministic' seasonal component plus an irregular component with stable variance. If there is a seasonal break in the series it will be reflected in SI ratios.

41 The following casus are mentioned in 'Guide to Seasonal Adjustment', (2007). Fast moving seasonality means that the seasonal pattern displays rapidly evolving fashion from year to year.

42 The procedure of withdrawing spans from time series is described in FINDLEY, D., MONSELL, B. C., SHULMAN, H. B., and PUGH, M. G. (1990) as follows: "To obtain sliding spans for a given series, an initial span is selected whose length depends on the seasonal adjustment filters being used. A second span is obtained from this one by deleting the earliest year of data and appending the year of data following the last year in the span. A third span is obtained from the second in this manner, and a fourth from the third, data permitting. This is done in such a way that the last span contains the most recent data".

The summary of the sliding spans analysis is presented below. It contains information about spans, results of the seasonality tests for each span and means of seasonal factors for each month in each span. For seasonality tests' descriptions see the Annex (section 12A).

Sliding spans summary

Time spans

Span 1: from 1-1998 to 11-2006
Span 2: from 1-1999 to 11-2007
Span 3: from 1-2000 to 11-2008
Span 4: from 1-2001 to 11-2009

Tests for seasonality

	Span 1	Span 2	Span 3	Span 4
Stable seas.	72,6	66,3	53,6	45,2
Kruskal-Wallis	68,6	74,4	77,5	76,3
Moving seas.	0,9	0,3	0,4	0,6
Identifiable seas.	YES	YES	YES	YES

Means of seasonal factors

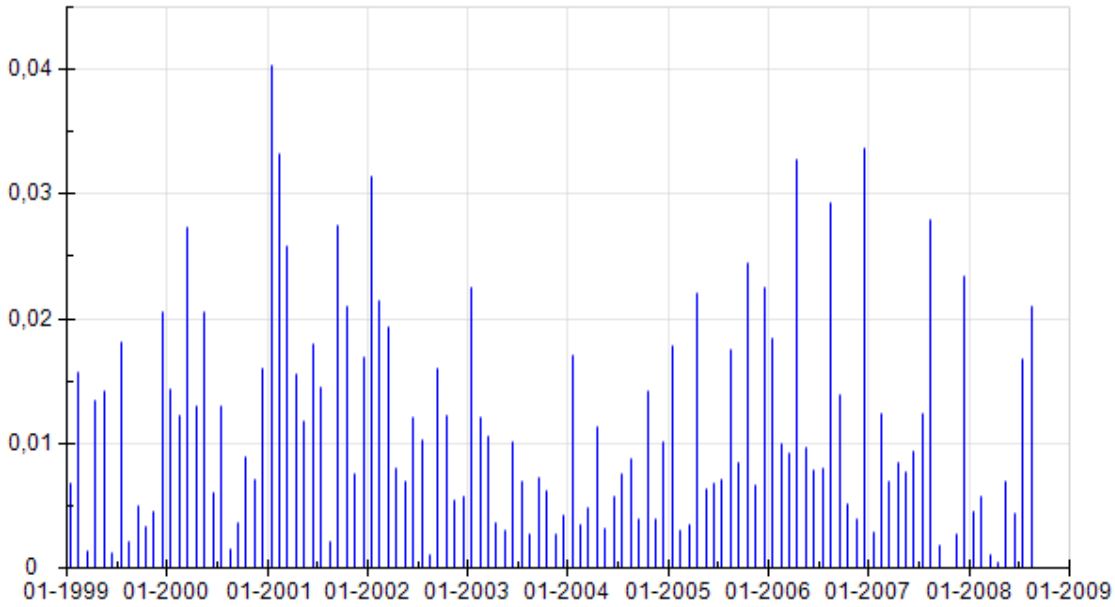
	Span 1	Span 2	Span 3	Span 4
January	1,0878	1,0697	1,0824	1,1212
February	0,8840	0,9067	0,9128	0,8949
March	0,8471	0,8513	0,8669	0,8489
April	0,8929	0,9149	0,9257	0,9322
May	0,7910	0,8006	0,7869	0,7692
June	0,7888	0,7623	0,7582	0,7752
July	0,9041	0,9240	0,9394	0,9650
August	0,8844	0,9050	0,9023	0,8854
September	0,8761	0,8776	0,8828	0,8726
October	1,0697	1,0984	1,1071	1,0856
November	1,1093	1,1037	1,0824	1,0920
December	1,8532	1,7882	1,7649	1,7665

The seasonal and the trading day's panels compare the (relative) changes of the levels of those components. The SA changes panel is related to period-to-period percent changes. When an additive decomposition is used, the sliding spans analysis uses absolute differences. The threshold to detect abnormal values is set to 3% of the testing statistics (see the Annex, section 11A)..

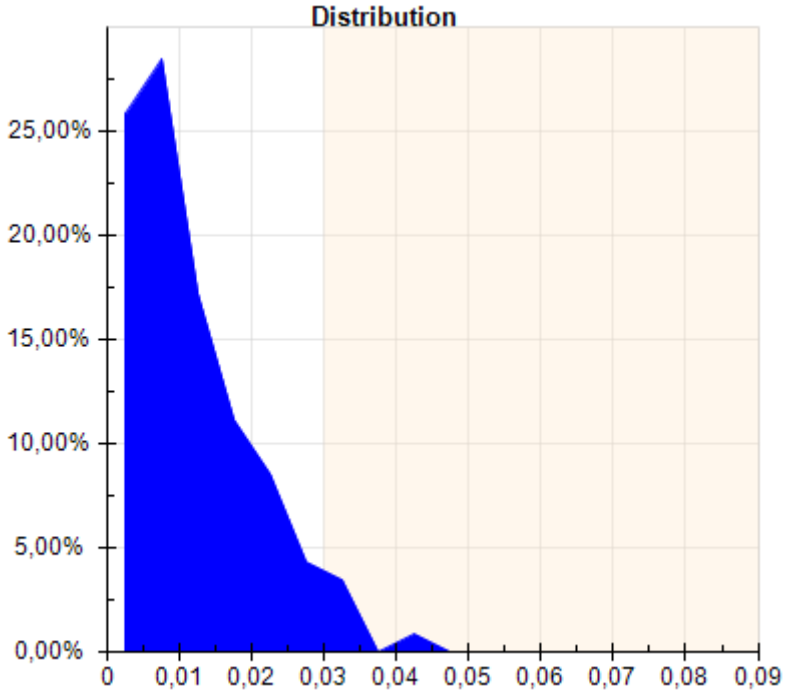
Detailed results of the sliding spans analysis is conducted separately for seasonal component, trading days effect and SA series (changes). The description of these results is the same for each part of the series. Below, explanation of the output for the sliding spans analysis for seasonal component is presented. The user should be aware that an unstable estimate of a month's seasonal factor can give rise to unstable estimates of the two associated month-to-month changes. Because of that, in majority of cases more months are flagged for unreliable month-to-month changes than for unreliable seasonal factors[43].

The first panel shows the sliding spans statistic obtained for each period. This statistic calculates the maximum percentage difference in the seasonal factors for period (month or quarter) t. The estimation of seasonal component is regarded as unstable if statistic is greater than 3%. The exact statistic's formula is given in the Annex (section 11A).

43 FINDLEY, D., MONSELL, B. C., SHULMAN, H. B., and PUGH, M. G. (1990).



The next panel presents the cumulative frequency distribution of the sliding spans statistics (months or quarters) using frequency polygon. On the horizontal axis values of the sliding spans statistics are shown, while vertical axis presents the frequency (in percentages) of each class interval[44]. The example below shows distribution where the first label on the X-axis is 0.0025. This represents an interval extending from 0 to 0.005. This interval has a frequency 25%, which means that 25% the sliding spans statistics are in this interval.



44 In frequency polygon data presented on the horizontal axis are grouped into class intervals.

According to the FINDLEY, D., MONSELL, B. C., SHULMAN, H. B., and PUGH, M. G. (1990), the results' of seasonal adjustment are stable if the percentage of unstable (abnormal) seasonal factors less then 15% of total number of observations. Empirical surveys support the view that adjustments with more than 25% of the months (or quarters) flagged for unstable seasonal factor estimates are not acceptable[45]. Therefore, the user should check the total frequency of the intervals between 0.03 and 1.

The last panel contains detailed information about the percentage of values for which the sliding spans condition is not fulfilled. In the example presented below 4.3% of values has been marked by the sliding spans diagnostic as abnormal. Moreover, Demetra+ provides information about number of breakdowns of unstable factors and average maximum percent differences grouped by month (or quarter) and by year. It gives idea weather observations with unreliable adjustment cluster in certain calendar periods and whether their sliding spans statistics barely or substantially exceed the threshold. The table below presents that two slinging spans statistic calculated for January have been above 3% and average maximum percent difference across spans for this period was 1.8.

Abnormal values : 4,3%

Breakdowns of unstable factors and Average Maximum Percent Differences across spans

Period	*Breakdowns*	*Average*
January	**2**	**1,8**
February	**1**	**1,3**
March	0	1,1
April	**1**	**1,3**
May	0	0,9
June	0	0,8
July	0	1,1
August	0	1,1
September	0	1,0
October	0	1,1
November	0	0,5
December	**1**	**1,7**

Year	*Breakdowns*	*Average*
1999	0	0,9
2000	0	1,2
2001	**2**	**2,0**
2002	1	1,3
2003	0	0,8
2004	0	0,8
2005	0	1,2
2006	**2**	**1,5**
2007	0	1,0
2008	0	0,8

45 FINDLEY, D., MONSELL, B. C., SHULMAN, H. B., and PUGH, M. G. (1990).

A large number of unstable estimates revealed by the sliding spans analysis supports an idea of changing the model's specification. The example of such a situation is presented below. Because of the large share of moving seasonality (for all spans test statistic is above 4), the test for presence of identifiable seasonality failed (see the Annex, section 12A for tests' descritpion).

Sliding spans summary

Time spans

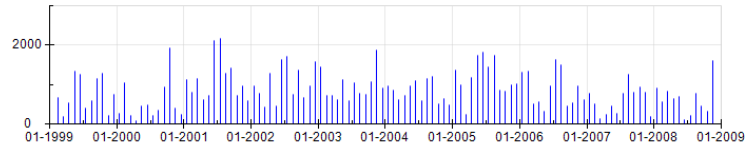
Span 1: from 1-1998 to 11-2006
Span 2: from 1-1999 to 11-2007
Span 3: from 1-2000 to 11-2008
Span 4: from 1-2001 to 11-2009

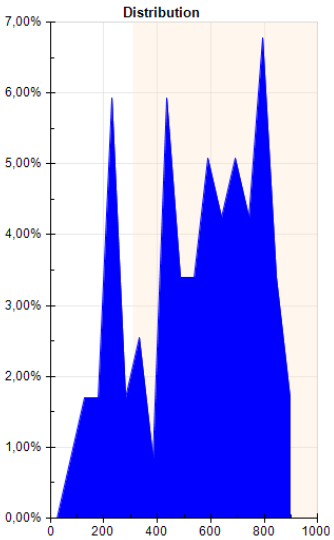
Tests for seasonality

	Span 1	Span 2	Span 3	Span 4
Stable seas.	6,7	6,6	7,0	7,3
Kruskal-Wallis	50,9	51,2	55,1	52,7
Moving seas.	4,4	4,7	4,8	4,1
Identifiable seas.	NO	NO	NO	NO

Means of seasonal factors

	Span 1	Span 2	Span 3	Span 4
January	221,813	97,6732	78,8923	143,397
February	-1521,15	-1508,5	-1473,18	-1376,74
March	-1421,88	-1632,14	-1742,64	-2038,82
April	-966,52	-700,687	-418,783	-510,623
May	-1682,99	-2182,04	-2264,85	-2265,83
June	-960,968	-949,774	-1034,25	-954,905
July	111,038	341,448	443,278	542,392
August	-1055,2	-1064,05	-870,327	-847,088
September	-1135,11	-864,588	-713,117	-1129,7
October	569,255	973,422	1102,41	1001,97
November	373,59	214,519	10,2962	421,368
December	7413,61	7305,25	6934	7034,75





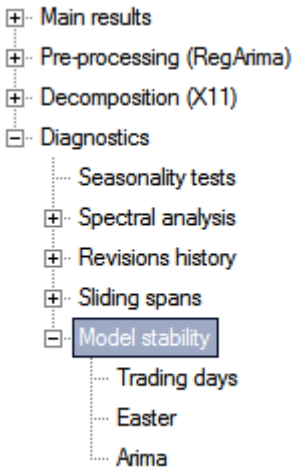
Abnormal values : 88,1%

Breakdowns of unstable factors and Average Maximum Differences across spans

Period	Breakdowns	Average
January	8	1016,4
February	10	829,1
March	6	506,5
April	8	652,0
May	10	824,5
June	8	1035,5
July	8	1024,3
August	10	1017,7
September	10	937,3
October	10	880,0
November	9	945,5
December	7	708,8

Year	Breakdowns	Average
1999	9	767,6
2000	7	555,0
2001	12	1142,5
2002	12	1047,8
2003	12	975,1
2004	12	813,8
2005	11	1186,0
2006	12	893,1
2007	8	596,5
2008	9	644,6

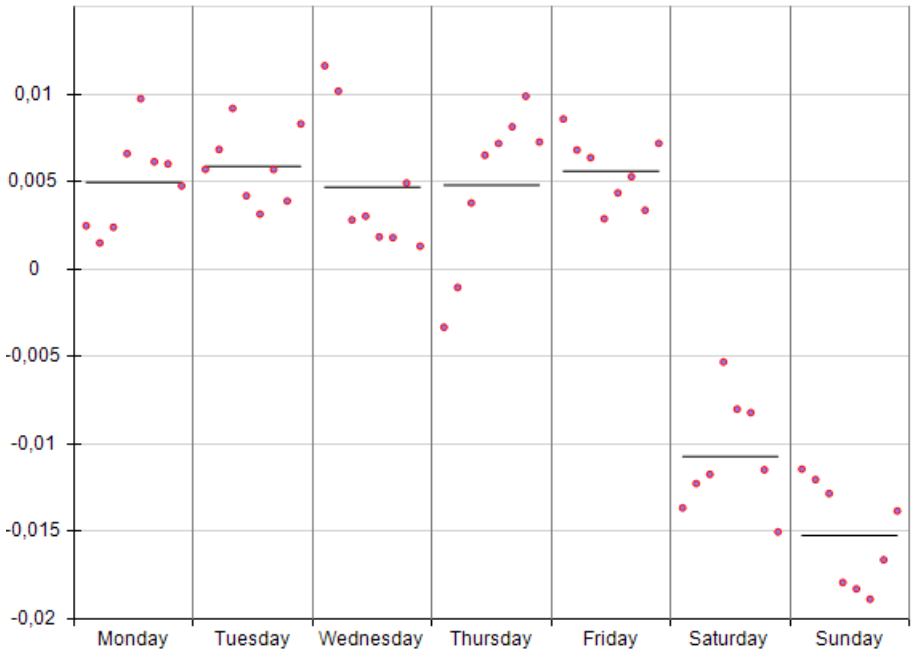
Model stability



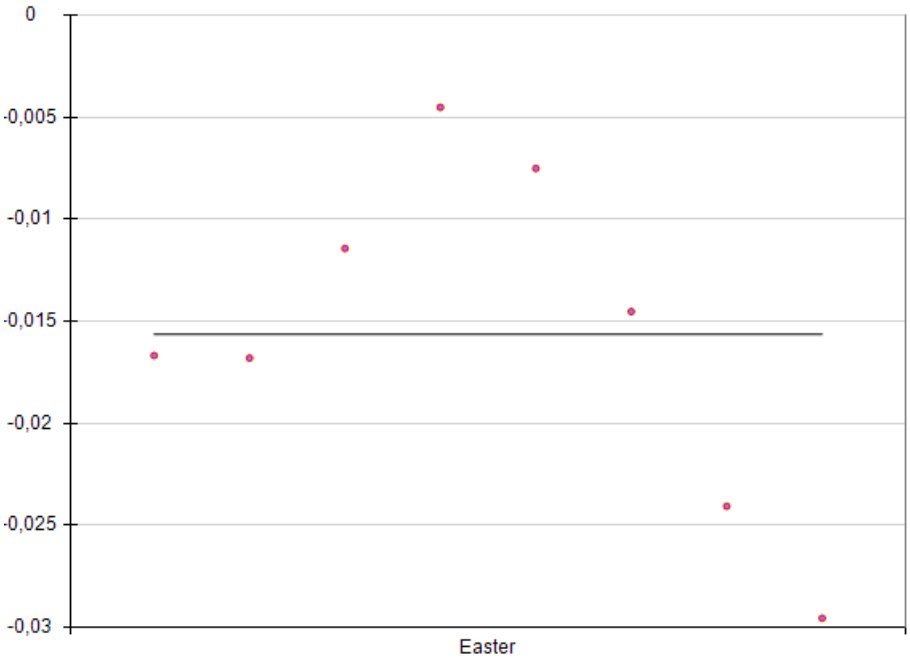
The diagnostics output window provides some purely descriptive features to analyze the stability of some parts of the model, like trading days, Easter and Arima. Model stability analysis calculates Arima parameters and coefficients of the regressors for different periods and visualizes these results on the graphics. The parameters of the model chosen for the complete time span are computed on a moving window. The length of the window is 8 years. The points displayed on the figure correspond to the successive estimations. The figures are helpful for assessing about the stability of the model parameters.

On the picture below the results of model stability diagnostic for trading days, Easter and Arima model are shown.

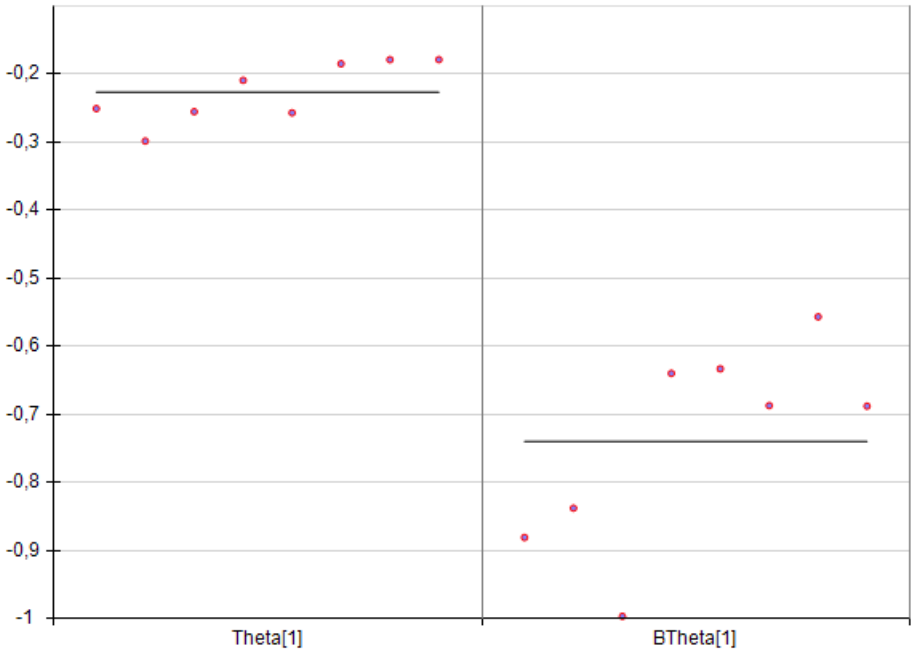
- **trading days parameters stability**



- **Easter effect parameter stability**



- **Arima parameters stability**



Small deviations from the mean parameter value are preferable. Taking into account a scale on the vertical axis, the most significant differencies between paramteres' values took place for Arima model parameters.

4.3.2.2. TramoSeats

The basic output structure is as follows:

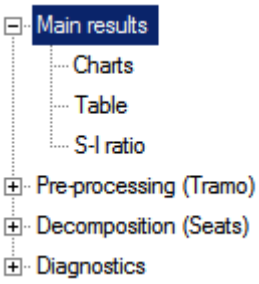
- Main results,
  - Charts,
  - Table,
  - S-I ratio,
- Pre-processing (Tramo),
  - Pre-adjustment series,
  - Arima,
  - Regressors,
  - Residulas,
- Decomposition (Seats),
  - Stochastic series,
  - Model-based tests,
  - WK analysis,
- Diagnostics,
  - Seasonality tests,
  - Spectral analysis,
  - Revisions history,
  - Sliding spans,
  - Model stability.

TramoSeats method and related concepts are presented in the Annex (section 4A). Detailed description of the seasonal adjustment outcomes is presented below. For those features that are very similar to the X12, appropriate descriptions and drawings are omitted. The user can find

those in Seasonal adjustment results for X12. In this section only issues specific for TramoSeats will be discussed in detail.

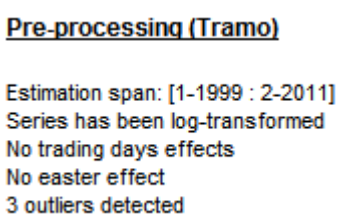
4.3.2.2.1. Main results

Basic information about seasonal adjustment and the quality of the outcomes are divided into three parts: Pre-processing (Tramo), Decomposition and Diagnostics.



First part contains results from Tramo. Information "Series has been log-transformed" is displayed if logarithmic transformation has been applied as a result of specification test done by Tramo. Otherwise, information does not appear. In case of RSA0, RSA1 and RSA3 specifications trading days effect is not estimated. For RSA2 and RSA4 specifications working days effect and leap year effect are pretested and estimated. If working day effect is significant, pre-processing part includes information "Working days effect (1 regressor)". "Working days effect (2 regressors)" means that also leap year effect is significant. For RSA5 specification trading days effect and leap year effect are pretested. If the trading days effect has been detected "Trading days effect (6 regressors)" or "Trading days effect (7 regressors)" is displayed, depending whether leap year effect has been estimated or not. If Easter effect is statistically significant in the series, "Easter effect detected" is displayed.

If RSA0 specification is used or any significant outliers have not been found under other specifications, "No outliers found" is displayed. In this section only total number of detected outliers is visible. More information, i.e. the type, date and coefficients of outliers are specified in node "Pre-processing (Tramo)".



Second part of Main results presents the variance of the white noise innovation for each component extracted by Seats procedure from the observed time series x_t. Observed time series x_t follows an Arima model of the type $\delta(B)x_t = \psi(B)a_t$, where a_t is a white-noise variable

with variance $V(a)$. The residuals a_t from this model are also called "innovations[46]" because they are the new (unpredictable at $t-1$) part of x_t. They are estimators of the one-period-ahead forecast error of the observed series x_t.
Seats decomposes a time series into four different orthogonal[47] components. These components are trend[48], seasonal, transitory and irregular. For additive decomposition original time series can be presented as a sum of the components:

$$x_t = \sum_{i=1}^{k} x_{it}$$

Each component follows the general Arima model:

$$\delta_i(B)x_{it} = \psi_i(B)a_{it}$$

where:

i - trend, seasonal, transitory or irregular components[49], respectively,

$a_{it} \sim WN(0, V(a_i))$ - assumed an .i.i.d. white-noise innovation of i component. It is also an estimator of the 1-period-ahead forecast error of component i.
$\psi_i(B) = \frac{\theta_i(B)}{\varphi_i(B)}$.

The polynomials $\theta_i(B)$, $\varphi_i(B)$ and $\delta_i(B)$ are of finite order. A white-noise variable is normally, identically and independently distributed, with a zero-mean and variance of the component _ innovation (the variance of the 1-period ahead forecast error of the component) $V(a_i)$. Two different components don't share the same unit autoregressive roots.

The components can be also expressed in compact form:

---

46 For definition of innovations refer to the Annex, section 5A.

47 Orthogonality means that behavior of each component is independent from other components. In particular, causes of seasonal fluctuations are independent from causes of long term evolution of the series.

48 Trend means trend-cycle.

49 It is assumed that irregular component is a white noise variable, which means that it follows ARIMA (0,0,0)(0,0,0) model.

$$\phi_i(B)x_{it} = \theta_i(B)a_{it}$$

where:

$\phi_i(B)$ is a product of the stationary and the non-stationary autoregressive polynomials.

Seats decomposition fulfills the canonical property, that is it maximizes the variance of the irregular component providing trend, seasonal and transitory as stable as possible (in accordance with the models) [50] .

For each component the value of innovation variance is represented through the ratio of the component innovation variance $V(a_i)$ to the component-Arima-model to variance of the series innovation $V(a)$ [51]:

$$k_i = Var(a_i)/Var(a)$$

k_i represents the ratio of component innovation variance to series innovation variance[52]. The variance of the irregular component is maximized while the others' are minimized considering the rule of canonical decomposition. Therefore, it is expected that $k_{irregular}$ would be greater than remaining k_i.

An example of the output is presented below:

Decomposition

trend. Innovation variance = 0,0972
seasonal. Innovation variance = 0,0551
irregular. Innovation variance = 0,1884

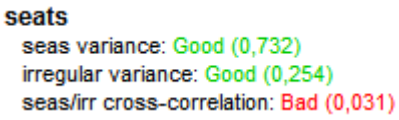
If some components have not been extracted by Seats from related time series (e.g. transitory component) they are not displayed in this section.

50 In order to identify the components Seats assumes that components are orthogonal to each other and each component except for the irregular one is clean of noise. This is called the *canonical* property, and implies that no additive white noise can be extracted from a component that is not the irregular one.

51 GOMEZ, V. and MARAVALL, A. (1998).

52 GOMEZ, V. and MARAVALL, A. (1998).

The Diagnostics includes the most important statistics which are informing the user about quality of the seasonal adjustment by reporting a summary of diagnostics. *Summary*, *Basic Checks*, *Visual spectral analysis*, *regarima residuals*, *residual seasonality* and *outliers* parts have been already described in 4.3.2.1. Seats diagnostics is characteristic only for TramoSeats method and shows results of the tests of assumptions made by Seats. In particular, *seas variance* and *irregular variance* show the probability value of a test to check whether the variance of estimators of the seasonal component and of the irregular component, respectively, is close to the variance of their actual estimates. The third test *seas/irr cross-correlation* checks theoretical crosscorrelation (between estimators) and empirical cross-correlation (between estimates).



For each of three tests three different results are possible. "Bad" means that the test statistics is significant at 1% level, "Uncertain" means that the test statistics is significant at 5% level and "Good" means that the test statistics is not significant at 5% level. Uncertain or bad results for *seas variance* may evidence over/under adjustment, for crosscorrelation may evidence too much correlation.

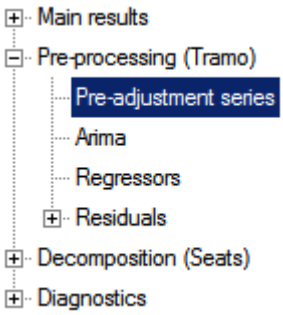
Additional information is available in three subsections: Charts, Table and S-I ratio.

In *Charts* section the user will find:

- the original series with forecasts,
- the final seasonally adjusted series,
- the final trend with forecasts,
- the final seasonal component with forecasts,
- the final irregular component,
- the final seasonal component with forecasts.

The same time series are presented in *Table* section. The final estimation of the seasonal-irregular component and final seasonal factors are presented in the *S-I ratio* chart.

4.3.2.2.2. Pre-processing (Tramo)



Pre-processing section is organized in the similar way in TramoSeats and X12. For details refer to RegArima description (4.3.2.1.2). Major differences between methods concern mostly *Arima* section.

Pre-adjustment series

The table presented in this section includes:

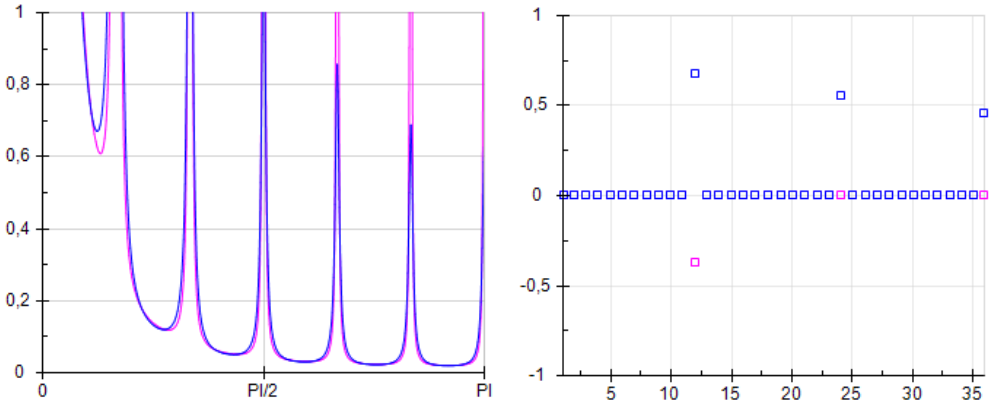
- series corrected by Tramo, i.e.:
    - interpolated series,
    - linearized series,
    - series corrected for calendar effects (if calendar effects are not specified it is the same as the interpolated series),
- deterministic effects detected and estimated by Tramo[53], i.e.:
    - deterministic component,
    - calendar effects,
    - trading days effect,
    - moving holidays effect,
    - outliers effect on trend component,
    - outliers effect on irregular component,
    - total outliers effect,
    - regression effect on seasonally adjusted series,

53 For particular time series the pre-processing table results includes only those deterministic effects that has been detected during estimation.

- regression effect on the trend component,
- regression effect on the irregular component,
- regression effect on the seasonal component.

Arima

Arima section shows the theoretical pseudo-spectrum of the Arima model estimated on the series (graph on the right) and the theoretical autocorrelation function of the stationary (arma) part of the model (graph on the left). The theoretical pseudo-spectrum is displayed in the top-left part. The blue line represents Arima model identified by Tramo. If this model has been changed by Seats, a second line in magenta, corresponding to the new Arima model, is overlapped. The theoretical auto-correlation of the stationary arma part of the model estimated in Tramo is presented in the top-right part in blue. If such model is changed by Seats, a second theoretical correlogram is shown in magenta. In the bottom part, estimated coefficients of parameters (regular and seasonal AR and MA) are shown in closed form (i.e. using the backshift operator B).



Tramo model

Polynomials

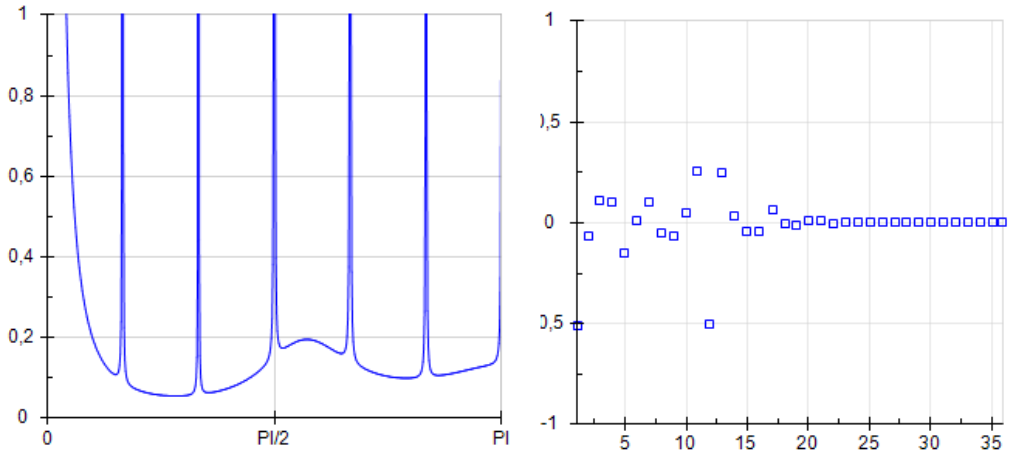
regular AR: 1
seasonal AR: 1 - 0,81888 S
regular MA: 1
seasonal MA: 1 - 0,27195 S

Seats model

Polynomials

regular AR: 1
seasonal AR: 1
regular MA: 1
seasonal MA: 1 - 0,42819 S

In this part, frequencies corresponding to regular AR roots are also reported (if present). This frequencies may represent tading-day effect or cycle of transitory component to be extracted in Seats.



Tramo model

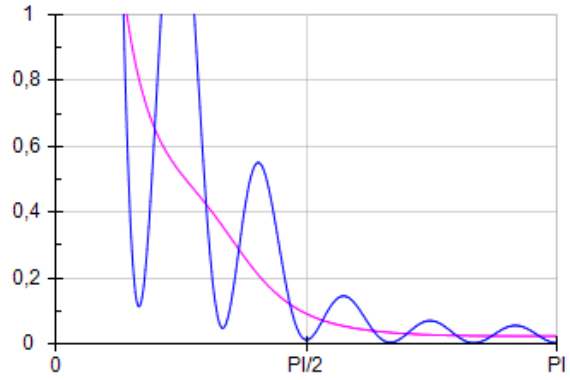
Polynomials

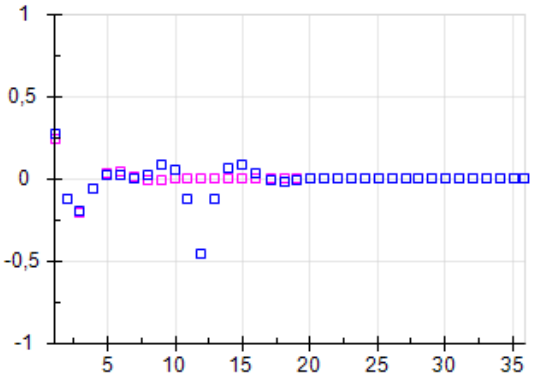
regular AR: 1 + 0,84816 B + 0,63239 B^2 + 0,27735 B^3
seasonal AR: 1
regular MA: 1
seasonal MA: 1 - 0,85116 S

Frequency of the regular AR roots

3,14159265358979
1,76525302873444

Frequency of AR roots is useful for detecting a stochastic trading days effect or stationary seasonality. As it is shown in the picture below, Demetra+ highlights such values in the output (red color and warning).





Tramo model

Polynomials

regular AR: 1 - 0,31167 B + 0,18514 B^2 + 0,10083 B^3
seasonal AR: 1
regular MA: 1
seasonal MA: 1 - 0,63761 S

Frequency of the regular AR roots

3,14159265358979
1,04669433030803 (seasonal frequency)

Seats model

Polynomials

regular AR: 1 - 0,26757 B + 0,15759 B^2 + 0,12744 B^3
seasonal AR: 1
regular MA: 1
seasonal MA: 1

Frequency of the regular AR roots

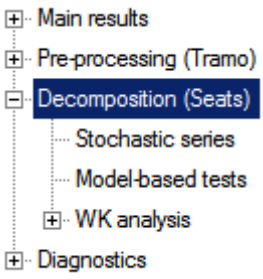
3,14159265358979
1,04222752219647 (seasonal frequency)

Regressors and Residuals

Regressors section presents all deterministic regressors used in Tramo part, including trading days variables, leap year effect, Easter effect, outliers, ramps, intervention variables and other user-defined variables.

In the next part the residuals which are obtained after estimation of Arima model in Tramo are presented both in the graph and the table. Analysis of the residuals consists of several tests and residuals' distribution.

4.3.2.2.3. Decomposition



Seats receives from Tramo the "linearized" series (original series corrected for the deterministic effects and missing observations). The decomposition made by Seats assumes that all components in time series - trend, seasonal and irregular - are orthogonal and could be expressed by Arima model[54]. Identification of the components requires that only irregular components include noise. Each model is presented in closed form (i.e. using the backshift operator B). In the main page of Decomposition (Seats), the following items are presented:

- Model - Arima model for the series,
- Trend - Arima model for the trend component of the series,
- Seasonal - Arima model for the seasonal component of the series,
- Transitory - Arima model for the transitory component of the series,
- Irregular - Arima model for the irregular component of the series.

The trend-cycle component captures the low-frequency variation of the series and displays a spectral peak at frequency 0. On the contrary, the seasonal component captures the spectral peaks at seasonal frequencies and the irregular component captures white noise behavior. Transitory component contains short-term variability associated with low-order MA components (of order Q - P, when Q > P) and AR roots with small moduli that should not be included in the trend-cycle or seasonal component. Moreover, transitory component captures periodic fluctuation with period longer that a year associated with a spectral peak for a frequency between 0 and $\frac{2\pi}{s}$ (where s is a number of observations per year)[55] and periodic fluctuation with spectral peak for intraseasonal frequencies.

.

54 It is assumed that irregular component is a white noise variable, which means that it follows ARIMA (0,0,0)(0,0,0) model.

55 MARAVALL, A. (1995).

The example of time series decomposition calculated by Seats is presented below. It can be seen that overall autoregressive polynomial has been factorized into polynomials assigned to the components according to the roots' frequencies. As an example, the model for trend is: $(1-2B+B^2)\cdot(1)\cdot x_{trend,t} = (1+0{,}059791B-0{,}94021B^2)\cdot a_{trend,t}$. The innovation has the highest variance (0,1454) and follows ARIMA (0,0,0)(0,0,0) model ($(1)\cdot(1)\cdot x_{innovation,t} = (1)\cdot a_{innovation,t}$).

Decomposition

Model
Non-stationary AR: 1 - B - B^12 + B^13
Stationary AR: 1 + 0,36007 B + 0,3327 B^2
MA: 1 - 0,47638 B^12
Innovation variance: 1,0000

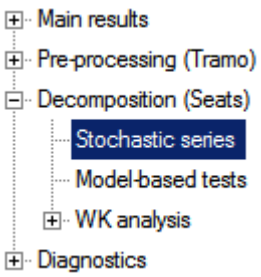
trend
Non-stationary AR: 1 - 2 B + B^2
Stationary AR: 1
MA: 1 + 0,059791 B - 0,94021 B^2
Innovation variance: 0,0465

seasonal
Non-stationary AR: 1 + B + B^2 + B^3 + B^4 + B^5 + B^6 + B^7 + B^8 + B^9 + B^10 + B^11
Stationary AR: 1
MA: 1 + 1,3862 B + 1,1023 B^2 + 1,1469 B^3 + 1,0739 B^4 + 0,81941 B^5 + 0,62328 B^6 + 0,41212 B^7 + 0,25791 B^8 + 0,024671 B^9 - 0,01917 B^10 - 0,15503 B^11
Innovation variance: 0,1110

transitory
Non-stationary AR: 1
Stationary AR: 1 + 0,36007 B + 0,3327 B^2
MA: 1 + 0,50781 B - 0,49219 B^2
Innovation variance: 0,0571

irregular
Non-stationary AR: 1
Stationary AR: 1
MA: 1
Innovation variance: 0,1454

Stochastic series

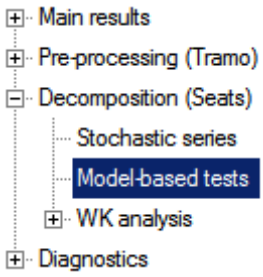


This part presents the table containing the following series produced by Seats:

- Seasonally adjusted series,
- Trend,
- Seasonal component,
- Irregular component (contains transitory component, if any),
- Trend (forecasts for 2 years),

- Seasonal component (forecasts for 2 years).

Model-based tests



Model based tests concentrate on distribution of components, theoretical estimators and empirical estimates (stationary transformation). This node is divided into tree sections.

- **Variance**

In this section the variances of the stationary transformation of the components (column "Component"), variances of theirs theoretical estimators (column "Estimators") and variances of theirs empirical (actually obtained) estimates (column "Estimate") are displayed[56] (see also section 4.3.2.2.1.).

Variance

	Component	Estimator	Estimate	PValue
trend	0,0490	0,0024	0,0021	0,3399
sa	2,1984	1,9304	1,9814	0,8210
seasonal	0,1730	0,0105	0,0081	0,5244
transitory	0,5150	0,2604	0,2327	0,3786
irregular	0,1866	0,0604	0,0581	0,7450

It follows from properties of model for the estimator that this estimator will always underestimate the component (estimators always have a smaller variance than components). The size of underestimation depends on the particular model. The underestimation will be relatively large when the variance of the component is relatively small. It means that, for example, the trend estimator always has a smaller variance than trend component and the ratio of the two variances get further away from one as the trend becomes more stable. Therefore, the more stochastic the trend is, the less will its variance be underestimated. On the other hand, the

56 MARAVALL, A. (1995).

variation of a very stable trend will be extremely underestimated[57]. It means that the trend estimator provides a more stable trend than the one implied by the theoretical model[58].

For all components it is expected that[59]:

- Var(Component) > Var(Estimator)[60],
- Var(Estimator) is close to Var(Estimate)[61].

If for a component, Var(Estimator) >> Var(Estimate), then the component is underestimated. On the contrary, Var(Estimator) << Var(Estimate), indicates the overestimation of the component.

In the last column of the table p-values of the second over/under estimation tests are provided. Green p-value means "Good", yellow means "Uncertain" and red means "Bad".

If Var(Estimator)>Var(Estimate) for a particular component then:

- p-values in red indicate strong underestimation of the component variance,
- p-values in yellow indicate mild underestimation of the component variance,
- p-values in green indicate no underestimation of the component variance.

If Var(Estimator)<Var(Estimate) for a particular component then:

- p-values in red indicate strong overestimation of the component variance,
- p-values in yellow indicate mild overestimation of the component variance,
- p-values in green indicate no overestimation of the component variance.

• Autocorrelation function

The autocorrelation function (ACF) is the basic tool in the time domain analysis of a time series. For each component Demetra+ exhibits autocorrelations of stationary transformation of components, estimators and sample estimates. They are calculated from the first lag up to the

57 MARAVALL, A. (2005).

58 MARAVALL, A. (1993).

59 MARAVALL, A. (1997).

60 From TramoSeats structure it can be shown that estimator will always underestimate the component. The amount of the underestimation depends n the particular model, as a rule, the relative underestimation will be large when the variance of the component is relatively small, MARAVALL, A. (1995).

61 The theoretical variance (Estimator) should be similar to the estimate actually obtained (Estimate). Large differences between the theoretical and empirical values would indicate misspecification of the overall model, MARAVALL, A. (1995).

seasonal lag. If the model is correct, the empirical estimate of autocorrelation function should be close to the theoretical estimator autocorrelation function. For i-th component the discrepancy between ACF function of the components and of the estimator can be substantial for small values of innovation variance $Var(a_i)$. If the components derived from the time series vary with stability, the distortion in the ACF of the components induced by estimation is stronger for the more stable (with low $Var(a_i)$) one. It means that these distortions are large when components have a low importance[62].

For ACF functions Demetra+ presents the following tables:

trend

Lag	Component	Estimator	Estimate	PValue
1	0,0002	0,4481	0,3811	0,1288
2	-0,4998	-0,1863	-0,2069	0,7770
3	0,0000	-0,1922	-0,0565	0,0621
4	0,0000	-0,1191	-0,0793	0,6281
5	0,0000	-0,0972	-0,2186	0,1521
6	0,0000	-0,0650	-0,0955	0,6948
7	0,0000	-0,0453	-0,0049	0,6417
8	0,0000	-0,0278	-0,0589	0,7231
9	0,0000	-0,0092	-0,0182	0,9181
10	0,0000	-0,0016	-0,0077	0,9440
11	0,0000	-0,0687	-0,0782	0,9114
12	0,0000	-0,1275	0,0334	0,0394

sa

Lag	Component	Estimator	Estimate	PValue
1	-0,4566	-0,4585	-0,4479	0,8110
2	-0,1605	-0,1575	-0,2361	0,3170
3	0,1171	0,1160	0,2298	0,1499
4	0,0000	0,0000	0,0491	0,5541
5	0,0000	0,0000	-0,1603	0,0551
6	0,0000	0,0000	0,0430	0,5673
7	0,0000	0,0000	0,0933	0,2642
8	0,0000	0,0000	-0,0995	0,2303
9	0,0000	-0,0134	0,0008	0,8632
10	0,0000	0,0182	0,1396	0,1425
11	0,0000	0,0529	-0,1771	0,0054
12	0,0000	-0,1154	0,0196	0,0728

62 MARAVALL, A. (1993).

transitory

Lag	Component	Estimator	Estimate	PValue
1	0,5000	0,4461	0,3755	0,1079
2	0,0000	-0,1901	-0,2134	0,7481
3	0,0000	-0,1953	-0,0593	0,0600
4	0,0000	-0,1213	-0,0815	0,6268
5	0,0000	-0,0990	-0,2241	0,1389
6	0,0000	-0,0663	-0,1048	0,6191
7	0,0000	-0,0463	-0,0062	0,6442
8	0,0000	-0,0284	-0,0514	0,7929
9	0,0000	-0,0096	-0,0159	0,9415
10	0,0000	-0,0017	-0,0123	0,9035
11	0,0000	-0,0689	-0,0779	0,9168
12	0,0000	-0,1279	0,0395	0,0317

irregular

Lag	Component	Estimator	Estimate	PValue
1	0,0000	-0,5114	-0,5105	0,9869
2	0,0000	0,1761	0,1004	0,3434
3	0,0000	-0,1161	-0,0172	0,2300
4	0,0000	0,0231	0,0508	0,7429
5	0,0000	-0,0307	-0,1324	0,2134
6	0,0000	-0,0021	0,0243	0,7351
7	0,0000	-0,0077	0,0360	0,5937
8	0,0000	-0,0069	-0,0418	0,6793
9	0,0000	0,0084	-0,0307	0,6457
10	0,0000	-0,0232	0,0995	0,1455
11	0,0000	0,0565	-0,1156	0,0358
12	0,0000	-0,1170	-0,0013	0,1368

P-values of this test are given in the last column of each autocorrelation table. The user should check whether the autocorrelation exist or not (special attention should be given to first and/or seasonal order autocorrelation)[63]. Th

The coefficients of the autocorrelation function of the irregular component are always null in the "Component" column, while are not null in the "Estimator" column. It is because the irregular component is a white noise; however its final theoretical estimator usually has a moving average structure.

Meaning of the p-value for autocorrelation tests

Value	***Meaning***
Good	no evidence for autocorrelation
Uncertain	a mild evidence for autocorrelation
Bad	strong evidence for autocorrelation

63 MARAVALL, A. (2000).

It should be stressed that this test gives no information about the direction of autocorrelation.

Comparison of the theoretical MMSE estimators with the estimates actually calculated can be used as a diagnostic tool. The closeness between estimators and estimates points towards validation of the results[64].

- ## Cross-correlation function

The decomposition made by Seats assumes orthogonal components. To test this assumption, Demetra+ calculates cross-correlations among the stationary transformations of both the estimators and actual estimates (theoretical components are uncorrelated). A table containing these correlations is presented (they refer to: trend and seasonal, trend and irregular, seasonal and irregular and, if the transitory is present, trend and transitory, seasonal and transitory, irregular and transitory.

Although components of the time series are assumed to be uncorrelated, their estimators can be correlated as estimator variance will always underestimate the component variance. The appearance of the cross-correlation between the estimators of components has been signaled as an inconvenience of the model-based approach[65]. For this reason correlations between the stationary transformations of the estimators and of the estimates actually obtained should be checked[66].

The last column (PValue) in the table below displays the results of the test for no correlations between components. The outcome of the test is signalized by the color of the p-value (see table above). In the example below, PValues are green, which indicates that all correlations are negligible, so for each component estimator and estimate provide similar results.

Cross-correlation

	Estimator	Estimate	PValue
trend/seasonal	-0,1513	-0,2073	0,5748
trend/transitory	-0,4470	-0,3754	0,4813
seasonal/transitory	0,0606	0,0108	0,6115
trend/irregular	-0,1025	-0,0494	0,4341
seasonal/irregular	0,0588	0,0268	0,4827
transitory/irregular	0,6499	0,6751	0,4228

It is expected that the theoretical cross-correlations between the component estimators will be close to their sample estimates[67].

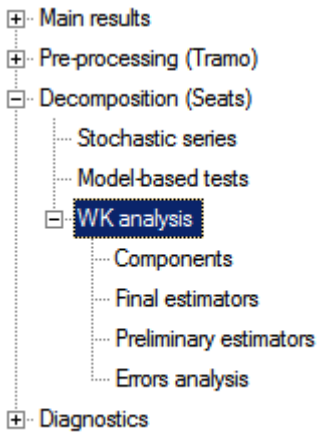
64 GOMEZ, V., and MARAVALL, A. (2001).

65 GOMEZ, V., and MARAVALL, A. (2001).

66 GOMEZ, V., and MARAVALL, A. (2001).

67 MARAVALL, A., and CANETE, D. (2011).

Wiener-Kolmogorow analysis



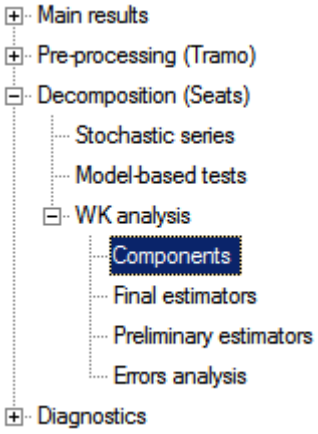
Wiener-Kolmogorow analysis concerns results obtained by Seats and concentrates on[68]:

- Components (spectrum, ACGF),
- Final estimators (spectrum, square gain function, WK filters, ACFG, PsiE-weights),
- Preliminary estimators (Frequency response (square gain function, phase effect), WK filter, ACFG),
- Revision analysis (total error, revision error).

This section presents various graphs concerning components of time series. As a rule, dark blue color indicates seasonally adjusted time series, navy blue indicates seasonal component, red indicates trend-cycle, green indicates transitory and pink indicates irregular component.

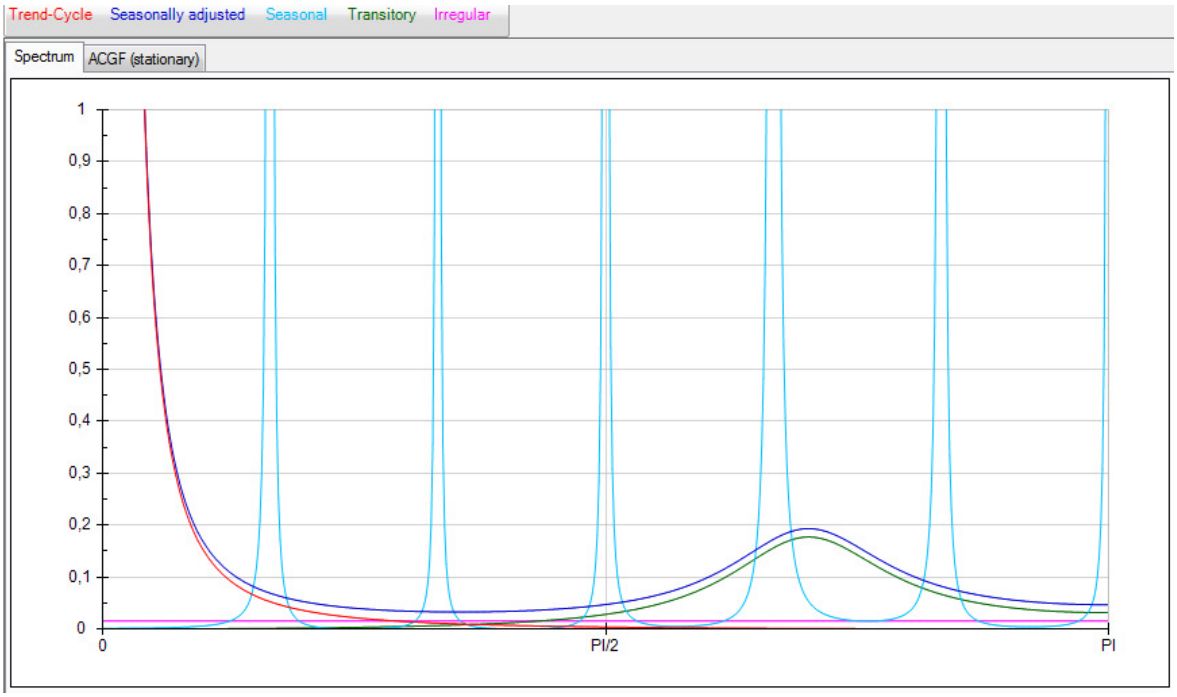
68 Wiener-Kolmogorow analysis is described in: e.g. MARAVALL, A. (1993), MARAVALL, A. (2008), MARAVALL, A. (2006), MARAVALL, A. (1995).

- **Components**

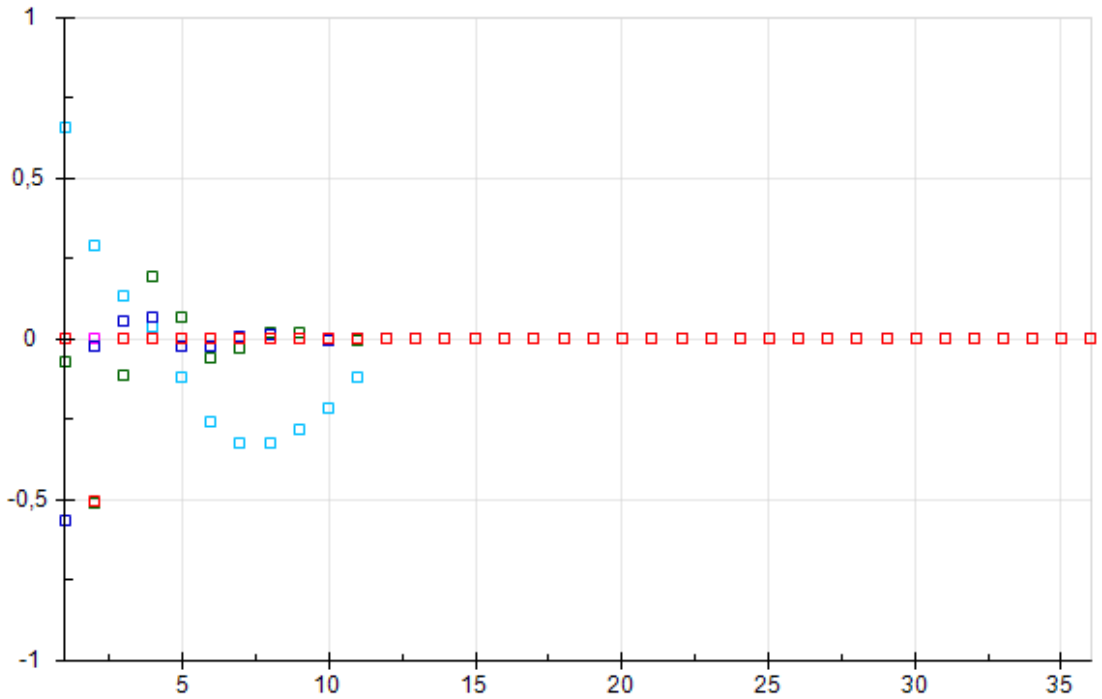


This section presents the (pseudo)spectra of the particular components. The sum of the components spectra should be equal to the spectrum for the observed time series, which is presented in the Pre-processing (Tramo) part (if the Tramo model has been accepted by Seats, the figure displays one spectra, otherwise spectra of the model chosen by Seats is visible). A seasonally adjusted series spectra (dark blue) is sum of trend-cycle component spectra (red), transitory component spectra (green), if present, and irregular component spectra (pink).

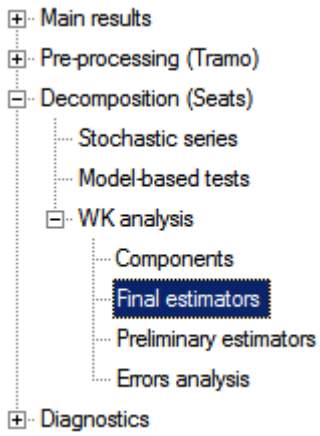
Since a_i generates the stochastic variability in the i-th component, small values of $V(a_i)$ are associated with stable component, large values of $V(a_i)$ with unstable component. The spectrum of the i-th component is proportional to $V(a_i)$. It means that stable trend and seasonal component are those with thin spectral peaks while unstable ones are characterised by wide spectral peaks. For monthly time series there are six seasonal frequencies, $\frac{\pi}{6},\frac{\pi}{3},\frac{\pi}{2},\frac{5\pi}{6},\pi$, while for quarterly data there are two seasonal frequencies, $\frac{\pi}{2},\pi$. Spectrum for seasonal component peaks around these frequencies. On the figure below the trend-cycle spectrum (red) is relatively narrow while seasonal peaks (light blue) are quite wide (especially the fourth and fifth) indicating large amount of stochastic seasonality. As a result seasonally adjusted spectra (dark blue) and spectra of transitory component (green) include peak which is an evidence of residual trading days effect.



Second panel shows ACGF (stationary) function. Values of the ACGF function are autocorrelation coefficients of stationary-inducing transformation of components. They are theoretical values (i.e. they are not computed on the data).



- **Final estimators**



TramoSeats uses seasonal adjustment filters to compute the values of different time series components. The convergence of these symmetric filters requires past and future time series observations, which are not available at the beginning and end of the time series. Hence, one needs to extend the time series from both ends (calculate forecasts and backcasts) to be able to use the filter. This is done by using the ARIMA-model, which is created in the TRAMO phase of seasonal adjustment. Then, Seats applies the filter to extended series (Cleveland and Tiao, 1976).

Regarding to the importance of final (or historical) estimators derived applying the WK filters (that are bi-infinite and symmetric filters), Demetra+ presents several graphics showing their properties (see the Annex, section 5A). The corresponding graphs for components and for final estimators of the components vary, as components and final estimators follow different models. For example, the seasonal component follows the model: $\delta_s(B)s_t = \psi_s(B)a_{st}$, while MMSE estimator of seasonal component follows model: $\phi_s(B)\hat{s}_t = \theta_s(B)\alpha_s(F)a_t$.

These graphics are listed below.

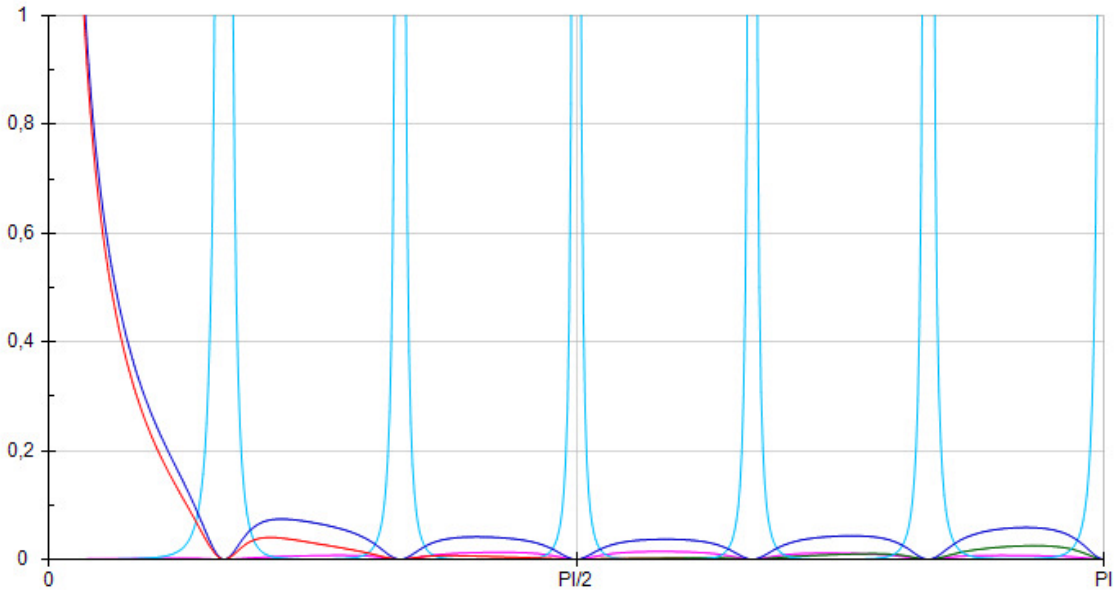
- **Spectrum of final estimators**

The shape of the spectrum of the final estimators is shown in the first graph. Spectrum of estimator of the seasonal component is obtained by multiplying squared gain of the filter by spectrum of the linearized series[69].

From the example below it is clear that these spectra are similar to those of the components, although estimator spectra show spectral zeros at the frequencies where the other components have spectral peaks. Estimator adapts to the structure of the analyzed series, i.e., the width of the

69 See the Annex, section 5A.

spectral holes in seasonally adjusted series (dark blue line) depends on the width of the seasonal peaks in the seasonal component estimator spectrum (navy blue lines)[70].



- **Squared gain of components filter**

The squared gain controls the extent in which a movement of particular amplitude at a frequency ω is delivered to the output series[71]. It determines how the variance of the series contributes to the variance of the component for the different frequencies. In other words, it specifies which frequencies will contribute to the signal (that is, it filters the spectrum of the series by frequencies)[72]. If squared gain is zero in band $[\omega_1, \omega_2]$ it means that the output series is free of movements in this range of frequencies[73]. On the contrary, if for some ω square gain is 1 then all variation is passed on to the component estimator.

The figure below points out that seasonal frequencies are assigned to the seasonal component while the seasonally adjusted series captures the variance of the non-seasonal part of the series. As a consequence, it is expected that seasonal component estimator captures only the seasonal frequencies, so its peaks assume unitary values at the latter frequencies.. On the contrary, estimator of the nonseasonal part of the time series is expected to eliminate seasonal frequencies, leaving unmodified non-seasonal frequencies. Therefore, squared gain of seasonally adjusted data should be nearly one apart from seasonal frequencies. In the next two figures,

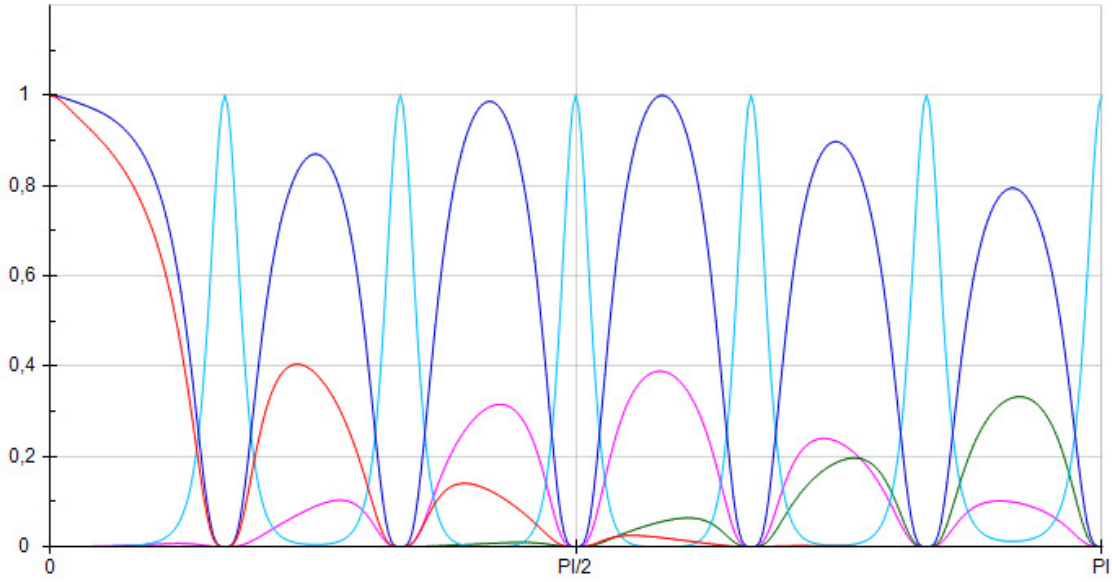
70 MARAVALL, A. (2003).

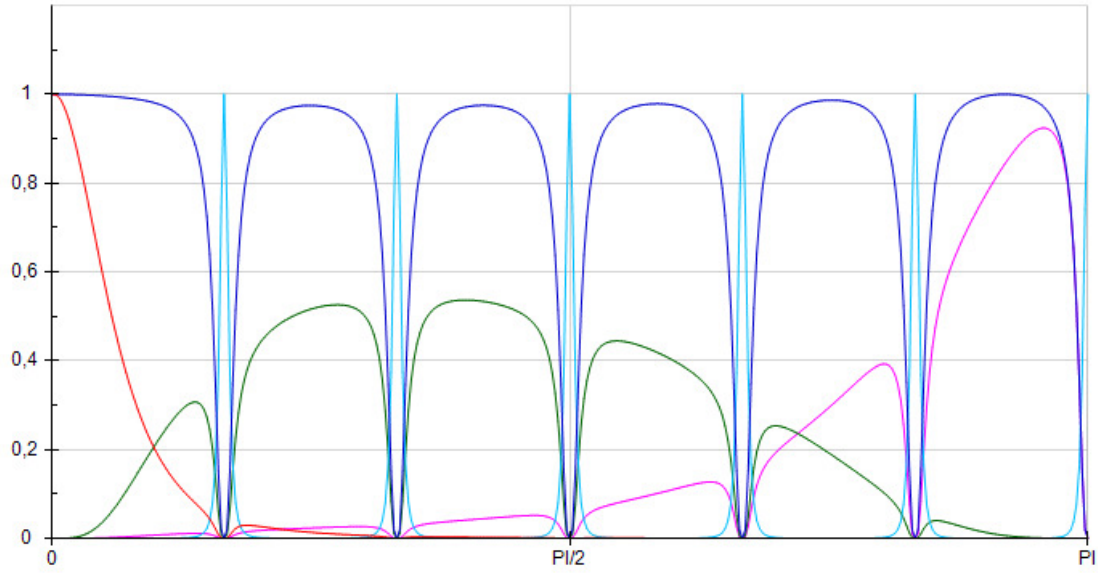
71 PLANAS, C. (1998).

72 Squared gain definition is given in the Annex, section 5A.

73 PLANAS, C. (1998).

squared gains derived from two different models are represented. In the first graph, the squared gain of the seasonal adjustment filter shows large throughs to suppress very erratic seasonal component, while in the second graph it shows more narrow throughs to remove a more stable seasonality.





- **WK filter**

Wiener-Kolmogorow filter $\nu_i(B,F)$ shows the weights that have been applied to the original series x_t to extract the $i-th$ component $\hat{x}_{it}$ in the following way (see the Annex, section 5A for description of the WK filter):

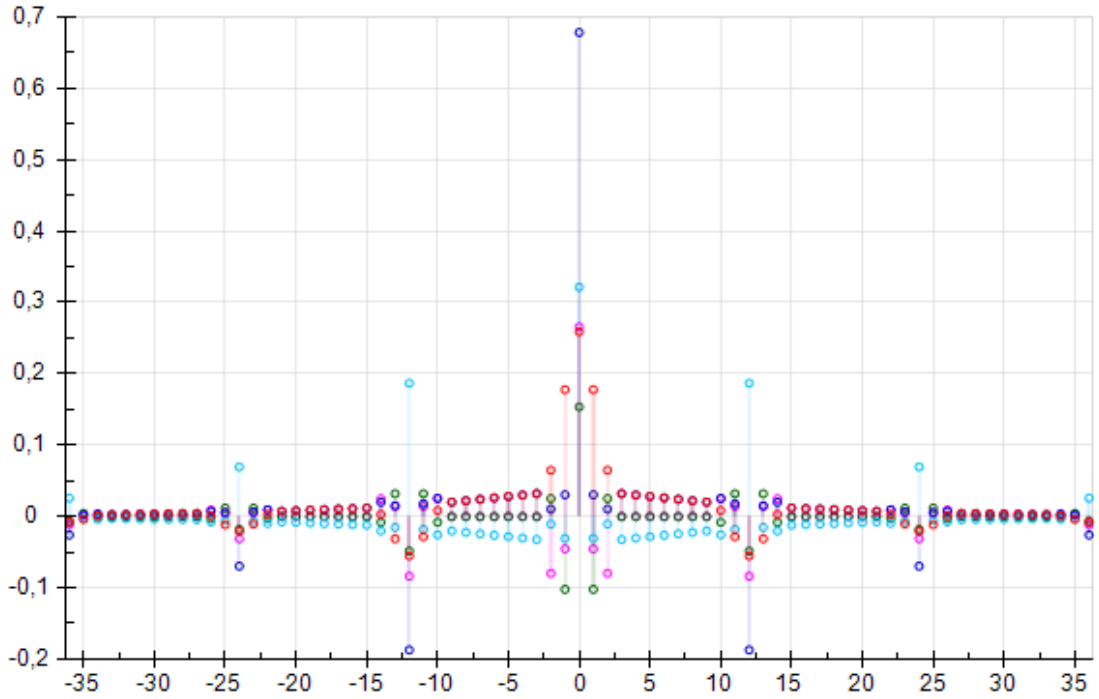
$$\hat{x}_{it} = \nu_i(B,F)\, x_t,$$

where:

$$\nu(B,F) = \upsilon_0 + \sum_{j=1}^{\infty} \upsilon_j (B^j + F^j),$$

Since WK filters are symmetric and centered. It is also convergent which enable to approximate infinite number of realization x_t by finite number of them (from the graph below it could be noticed that $j = 36$). In order to apply filter to all observations of the x_t, original time series is extended with forecasts and backcasts using ARIMA model. As new observation (i.e. observation for period $t+1$) is available, forecast for period $t+1$ is replaced by this new observation and all forecasts for periods $g > t+1$ are updated. It means that near the end of time series estimator of the component is preliminary and is a subject of revisions, while in the central periods estimator will be treated as final (also called "historical")[74].

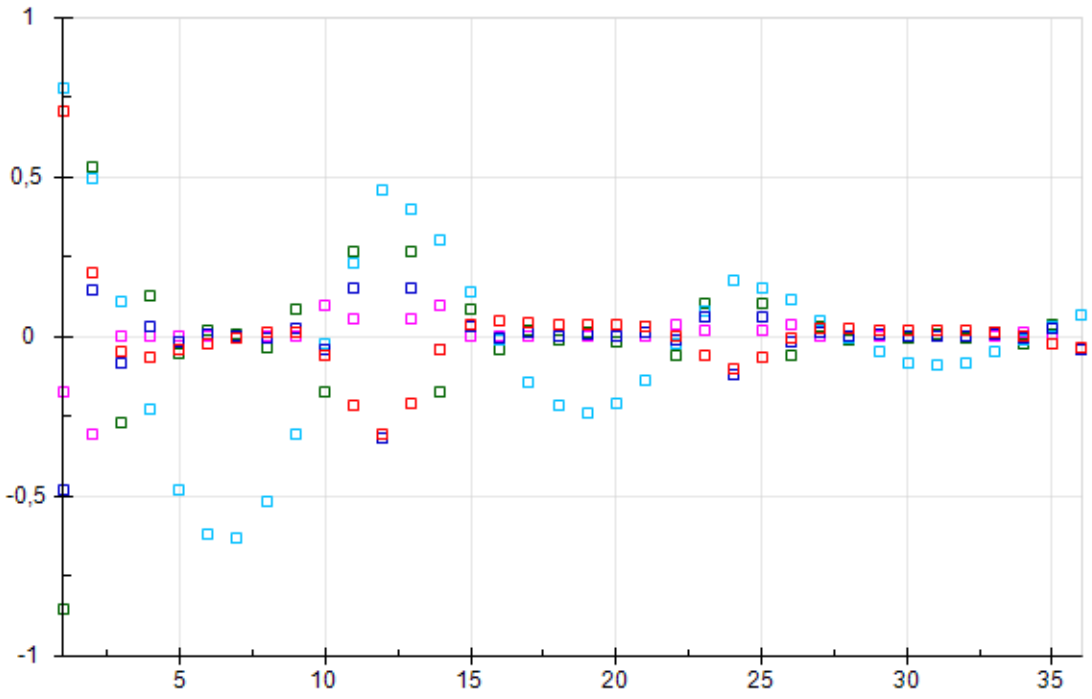
Since WK filters are symmetric and convergent, they are valid for computing the estimators in the central periods of the sample. The following graph demonstrates these features. The following graph demonstrates weights that are applied to the each observation for each component (weights applied to seasonally adjusted series are dark blue, to trend-cycle are red, to transitory component are green, and to irregular component are pink).



74 MARAVALL, A. (2011).

○ Auto-Correlation Generating Function

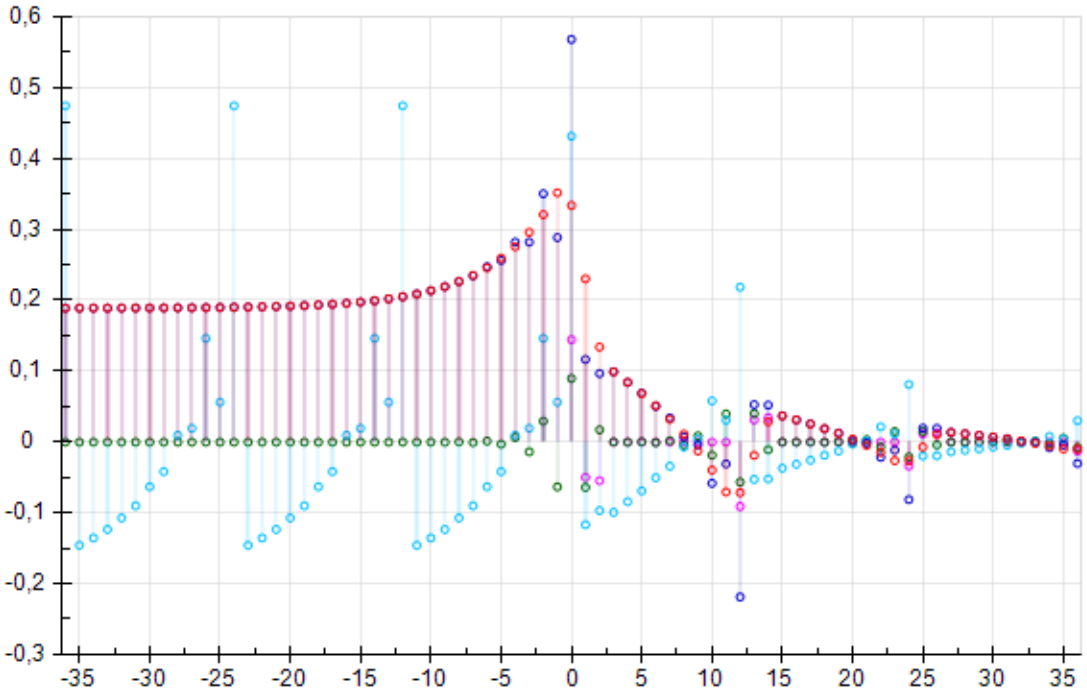
The window ACGF (stationary) displays the auto-correlation functions of the final estimators of the stationary components. The following graph represents an example.



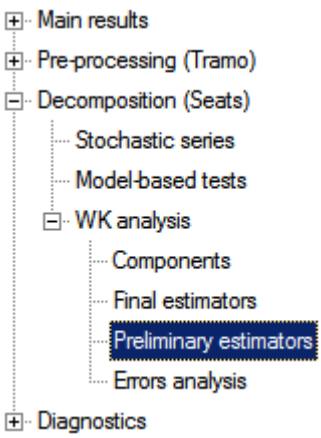
○ PsiE-weights

PsiE-weights (ψ) are a different representation of the final estimator, as they are applied to the innovation a_t, rather than on the series x_t[75]. For each component, figure below presents how the contribution of total innovation to component estimator $\hat{x}_{it}$ varies in time (the size of this contribution is shown in Y-axis). For observations ≥ 0 (X-axis) PsiE-weights show the effect of starting conditions, present and past innovations in series, while for observations < 0 they present the effect of future innovations. It can be seen that they are non convergent in the past (they are convergent when series x_t is stationary). On the contrary, the effect of future innovations is a zero-mean and convergent process. PsiE-weights are important to analyse convergence of estimators and revision errors.

75 See the Annex, section 5A. For more information see (Maravall, 2008).



- **Preliminary estimators**

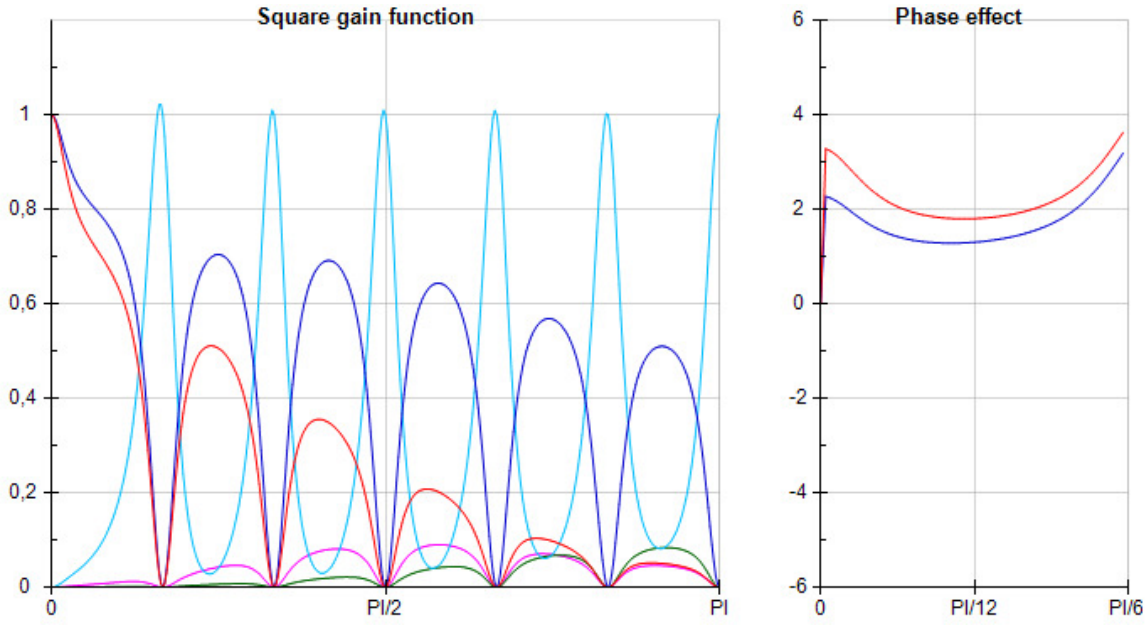


In this part different types of graphics are presented showing properties of preliminary estimators (estimated by WK filter) of each theoretical component. Preliminary estimators are obtained by replacing observations not yet available with forecasts and extending series with backcasts. Both forecasts and backcasts are obtained from Arima model. Then filter is applied to the extended series[76]. There, lag is set by default to zero, so the semi-infinite concurrent estimators $\hat{x}_{it|t}$ are considered. User can set a different lag, from 1 up to 60, and therefore consider semi-infinite preliminary estimators . $\hat{x}_{it|t+j}$.

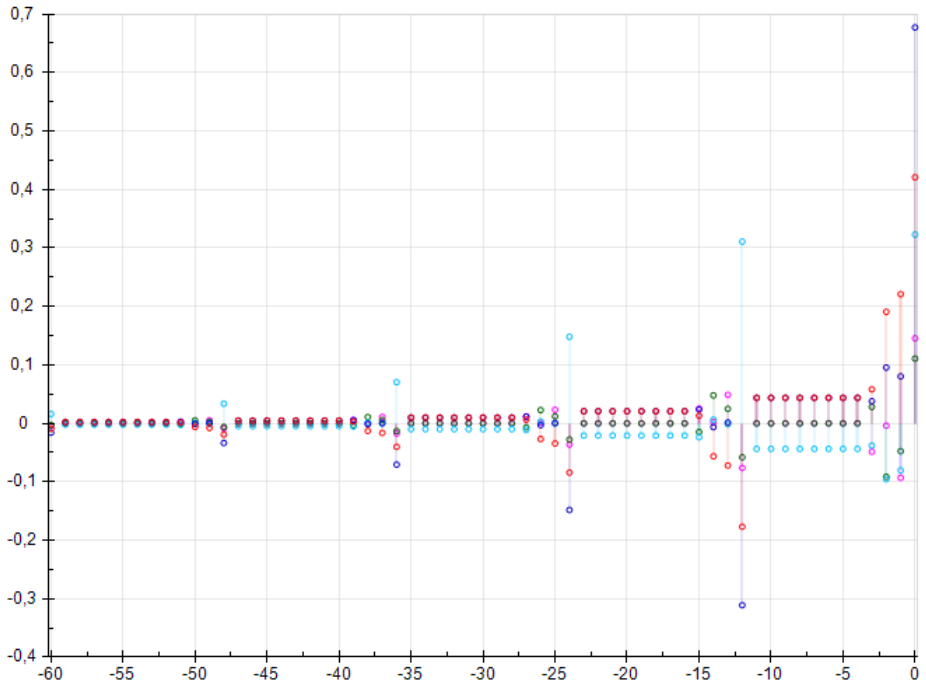
76 See the Annex, section 5A.

In this part different types of graphics, which show properties of preliminary estimators (estimated by WK filter) of each theoretical components, are presented.
The graphs include:

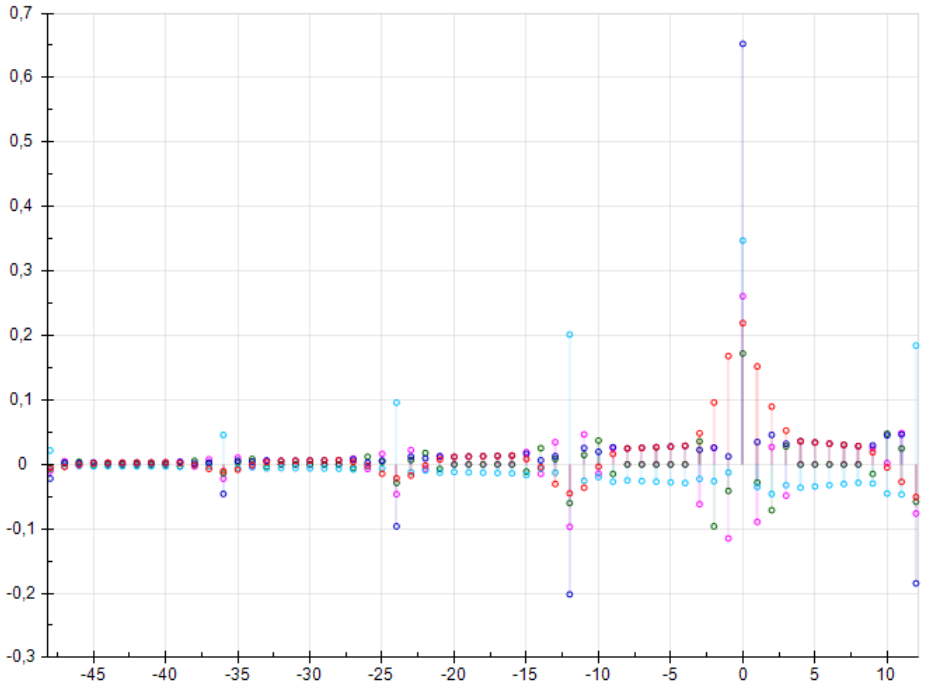
- "Frequency response" window contains two graphics, i.e. the squared gain function and the phase effect. Squared gain of preliminary estimators filter determines which frequencies will contribute to the component (that is, it filters the spectrum of the series by frequencies (see aforementioned description of the sugared gain). The phase effect graphics shows the phase shift in the seasonally adjusted series (or trend-cycle) in comparison with original series. It means that the phase effect indicates how frequency components are shifted in time by the filter, so it measures the difference in detecting turning points between original and seasonally adjusted data (or trend-cycle)_in terms of period (month or quarter). The phase effect function is calculated separately for seasonally adjusted series (red line) and trend-cycle (blue line). As a rule, phase effect has a positive value, which means that seasonally adjusted series (and trend-cycle) shows turning points later than original time series. This delay is undesired featured of seasonally adjusted time series and is regarded as a drawback by statisticians who use seasonally adjusted data for modeling and forecasting. For this reason it is expected that phase delay is zero (or nearly zero). The phase effect is measured in number of periods (horizontal axis). Vertical axis presents range of frequencies of cyclical interests. Frequencies close to 0 indicate long-term trend, while $\frac{Pi}{12}$ is a 2-year cycle. Hence, for monthly time series presented below, in seasonally adjusted data estimator induces high phase delay for the long-term and short term cycle (approximately 3 months), while for the 2 year-cycle phase delay is a bit smaller (2 moths).



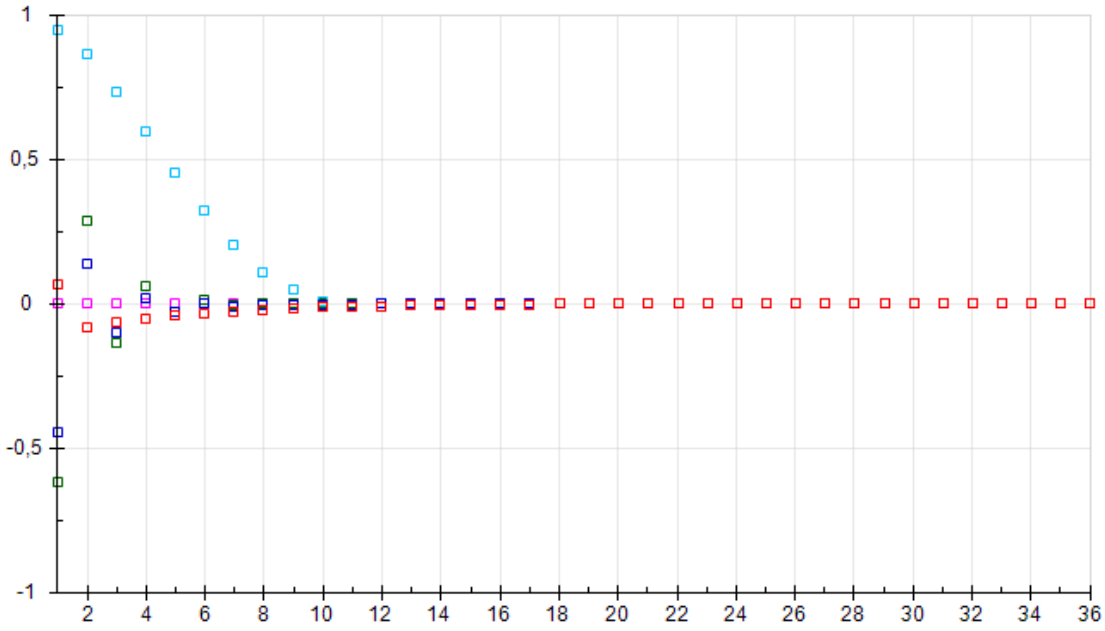
- WK filters. Preliminary component estimator will imply the one-sided (asymmetric) WK filter (see aforementioned description of the WK filter), and because of that will be adversely affected by phase effect.



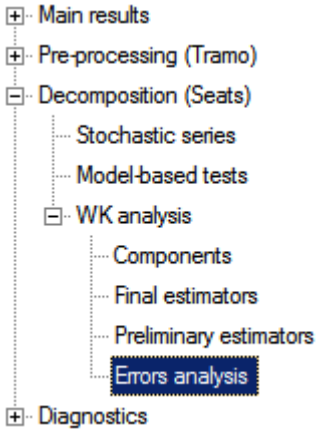
The graph below presents WK filter weights for lag=12 (i.e. for the observation x_{t-12} where t is the last available observation. It can be noticed that in this case WK filter uses both observations x_{t-12-i}, $i=1,2,...,48$ and observations x_{t+i}, $i=1,2,...,12$ to calculate preliminary component estimator).



- ACGF (stationary) represents auto-correlation functions of the preliminary estimators of the stationary components. For the preliminary estimators of the stationary components Demetra+ calculates ACGF for lag 0 to 60. The preliminary estimators imply the use of asymmetric filters, while when lag=0 the preliminary estimator is the concurrent one and it is obtained with a one-sided filter. The ACGF profiles of preliminary estimators when lag=60 (preliminary estimators approach the final ones), $x_{it|t+60}$, are very close to the profiles of the ACGF of final estimators. When the lag approaches 0, they differ more.



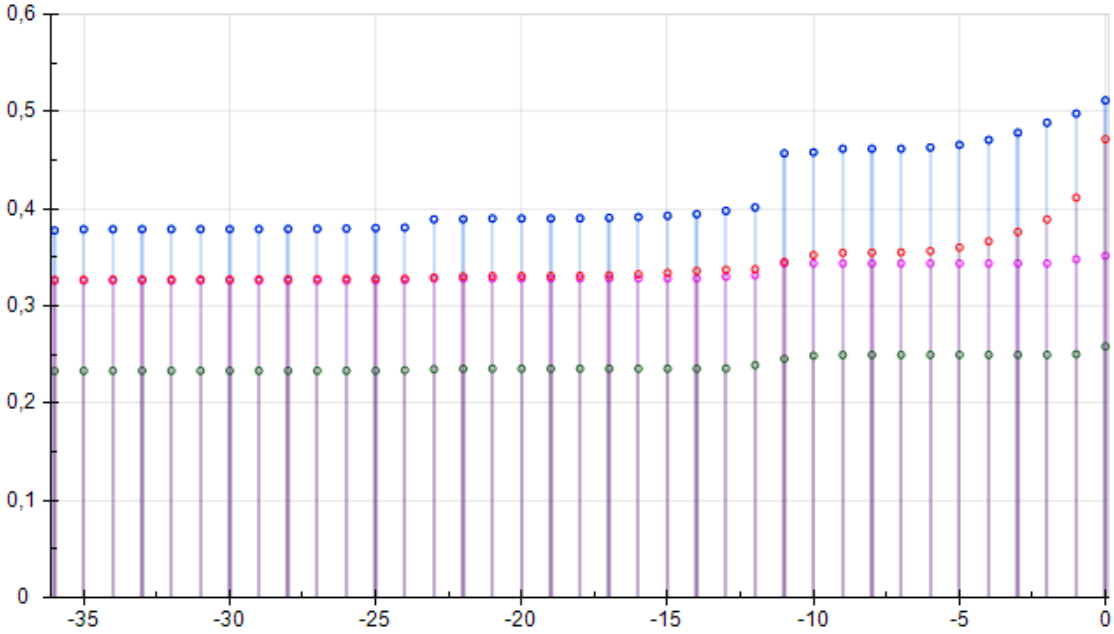
- **Errors analysis**



An error analysis is performed in last WK analysis node. Formulas for estimation errors are included in the Annex (section 5A).

- **Total estimation errors**

This panel reports the variance of the total estimation error of the trend-cycle, seasonally adjusted series, seasonal and irregular for concurrent estimators (lag = 0) and for preliminary estimators (lag <0). These variances are reported in units of the variance $V(a_t)$. The X-axis shows the duration of the revision process, i.e. how many periods it takes for a new observation to no longer significantly affect the estimate.

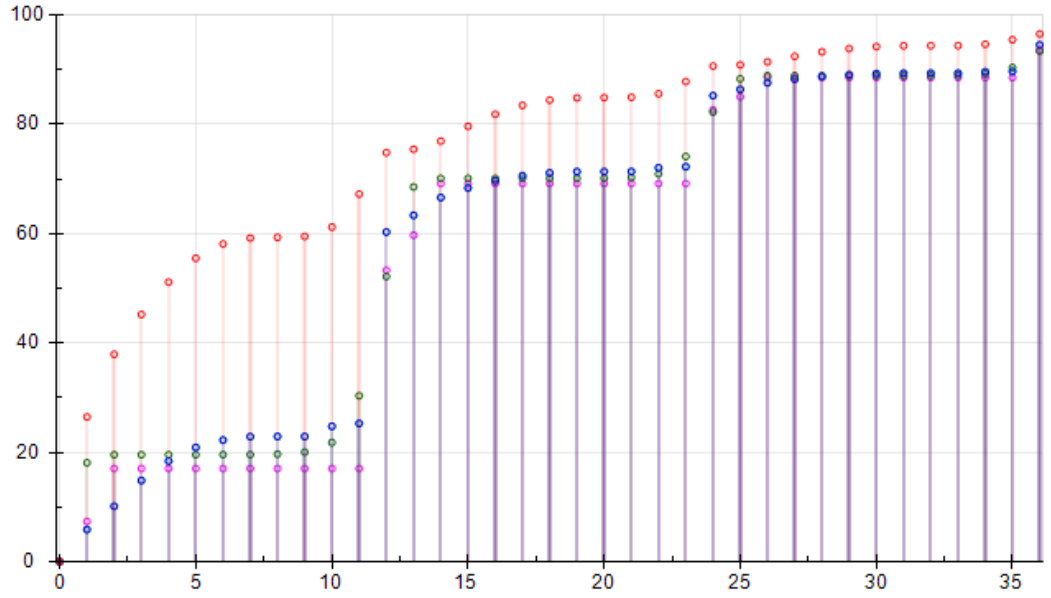


- **Revision error**

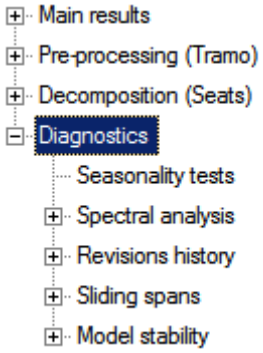
Revision error is the difference between preliminary and final estimator. For each component the graph shows the percentage reduction in the standard error of the revision after additional periods (up to 3 years). Comparisons are made with concurrent estimators. This graph gives information about the time needed by the concurrent estimators to converge to the final ones. As stressed in Maravall (1995), large revisions are associated to highly stochastic components and converge fast, while smaller revisions are implied by very stable components and converge slowly.

On the graph below X-axis presents periods (0 means the last available observation) and the Y-axis shows the decrease in size of the standard error of the revision in percentages. For the particular time series presented on the graph below, after one year of additional data (12 observations) the percentage reduction in the standard error of the trend revision was approximately 75% (80% for seasonally adjusted series). The trend estimator converges faster than that of the seasonally adjusted series because trend component was stochastic while seasonal component was rather stable[77]. After 3 years (36 observations) all estimators have practically converged (estimators are close to 100%).

77 MARAVALL, A. (1996).



4.3.2.2.4. Diagnostics



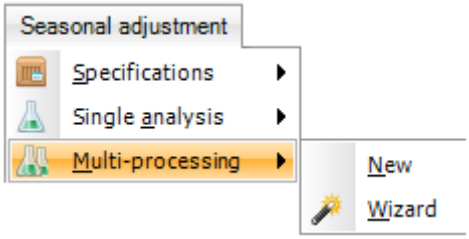
For TramoSeats Demetra+ calculates the following statistics:

- Friedman test,
- Kruskal-Wallis test,
- Test for the presence of seasonality assuming stability,
- Evaluative seasonal test,
- Residual seasonality test,
- Combined seasonality test.

In the Diagnostic section the user will find also Spectral analysis, Revisions history, Sliding spans, Model stability. For details please refer to Seasonal adjustment results for X12 and to the Annex. Description of the results and options available in Diagnostic section are presented in X12.

4.4. Multi-processing

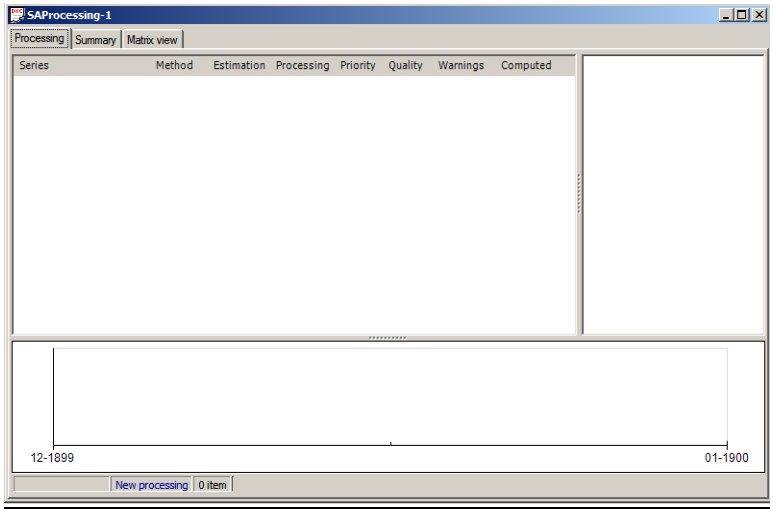
Multi-processing specification is designed for quick and efficient seasonal adjustment of large data sets. Multi-processing specifications that mix different seasonal adjustment methods are available. The software provides two different ways to perform multi-processing. The first solution is based on the "active" specification; in that solution, the series that are subject to in a multi-processing are automatically associated with the "active" specification. The second solution consists in using a wizard, which allows the users to associate series and specifications step by step. Both functions are activated from the main menu.



4.4.1. Defining a multi-processing

1. *Creation of a new multi-processing*

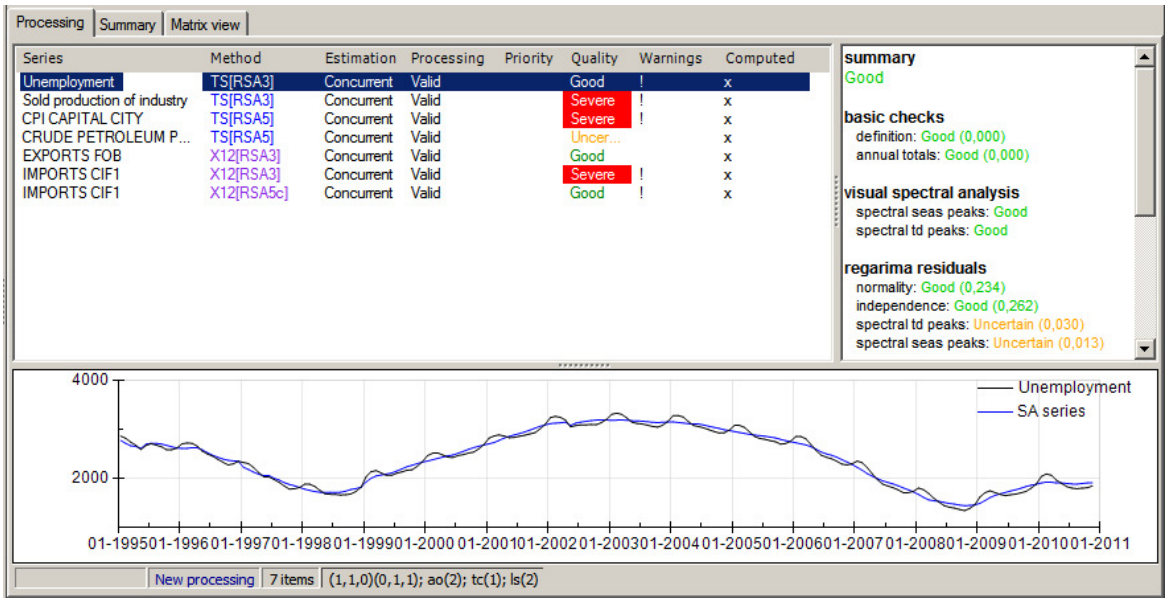
This option opens the following window.



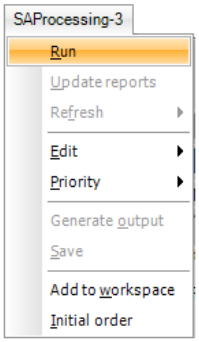
The user should first activate the specification and then drag and drop the time series into the window. We recall that the active specification can be selected in the workspace through a local menu; it can be either a pre-defined specification or a user-defined one. If there is no active specification in the *Workspace* panel, the user is unable to drag and drop time series into specification window.

The user can change initial choice of the active specification and choose other specification for next set of series. This option enables to launch the seasonal adjustment for one time series using

different specifications in order to compare the results. The picture below presents multiprocessing in which four different specifications has been used.



The processing is actually launched by means of the *Run* command under the *SAProcessing-1* main menu item.

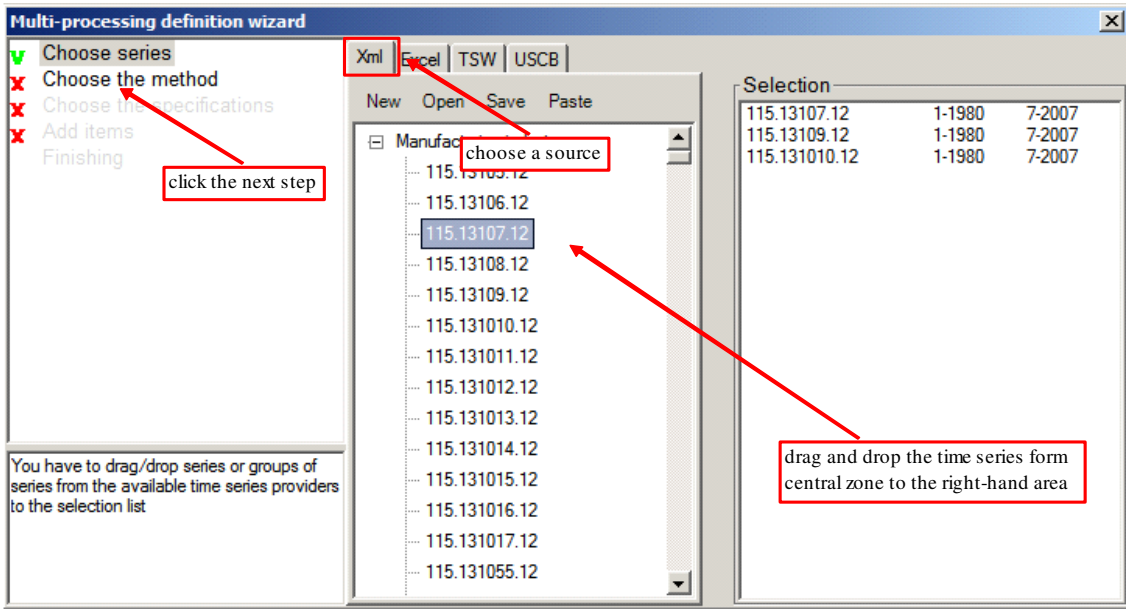


The user can also launch the seasonal adjustment of the time series by clicking on its name on the list.

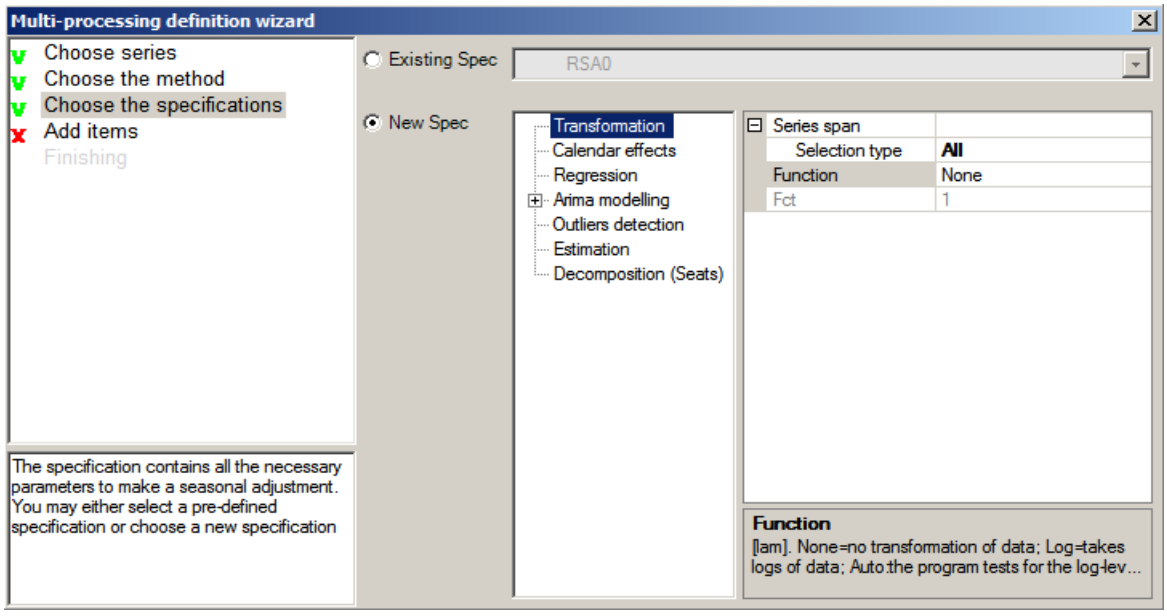
2. ***Creation of a multi-processing via wizard***

When the user activates the wizard, the empty window is displayed. The wizard guides the user through the construction of the associations "series-specifications". It also gives him the possibility to define and to use specifications that don't belong to the workspace.
Consecutive steps are similar to those which were described in single seasonal adjustment part. However, there are two main differences.

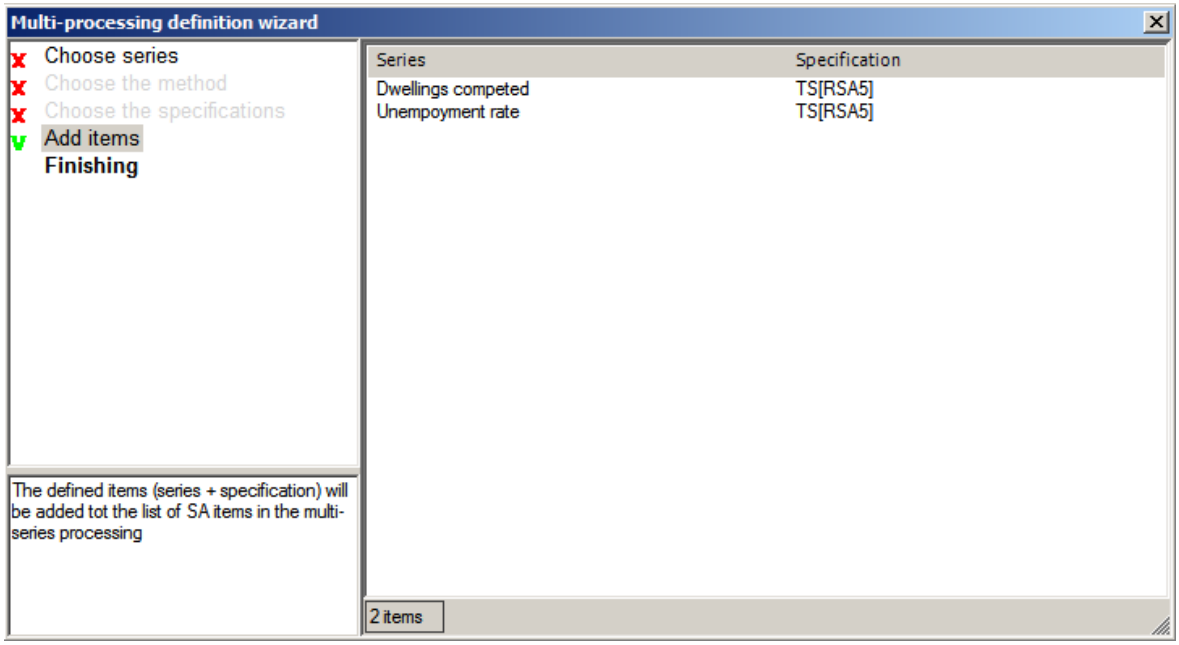
First of all, in the first panel the user can choose more than one time series and drop them into Selection window.



Then, the user should decide which seasonal adjustment method - X12 or TramoSeats - will be used. After that the user can chose existing specification or create new specification as it was shown in 4.1 and 4.2.



Next, in the add items Demetra+ presents time series which will be added to the list of seasonally adjusted items in the multi-series processing. Add items -part is not about adding time series to the regression part of the pre-adjustment model but simply shows the user the list of time series which have been chosen in the first step. It is not possible to add new time series to the multi-processing here.



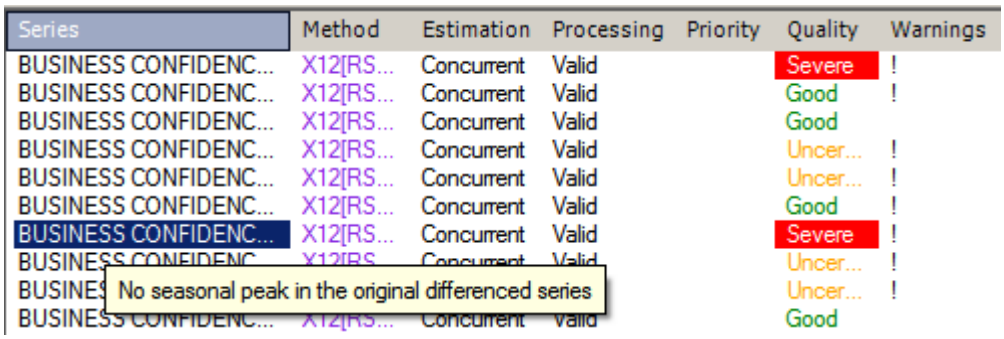
At the last stage of the wizard ("Finishing") the user can modify the name of the multiprocessing (SAProcessing-xx, default); one can also add the multi-processing to the workspace, for future re-use and the user can decide if the execution is automatically started (the default) when the wizard is closed. It should be mentioned that the user can go back to the first step of the wizard at any time, if one wants to add other series with other specifications.

4.4.2. Seasonal adjustment results for multi-processing

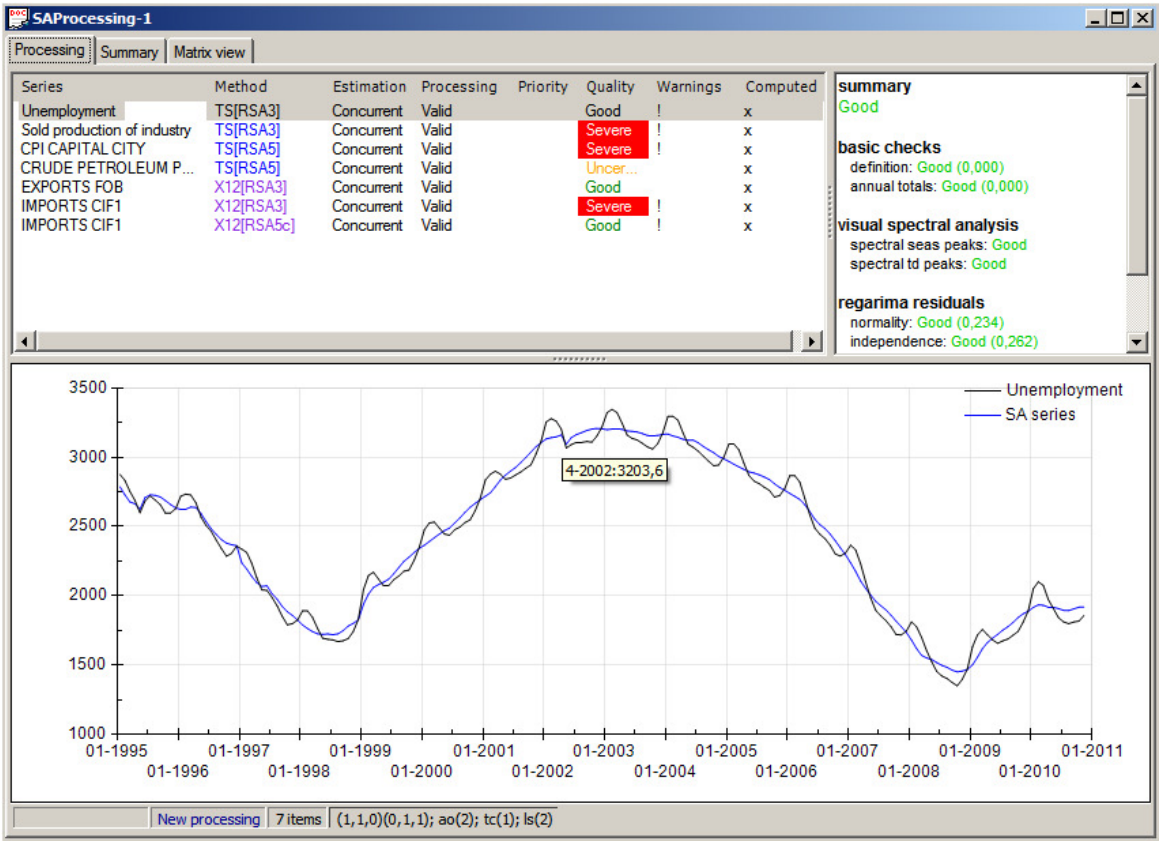
4.4.2.1. Generalities

The outcome of the multi-processing is presented in the window which contains three panels.

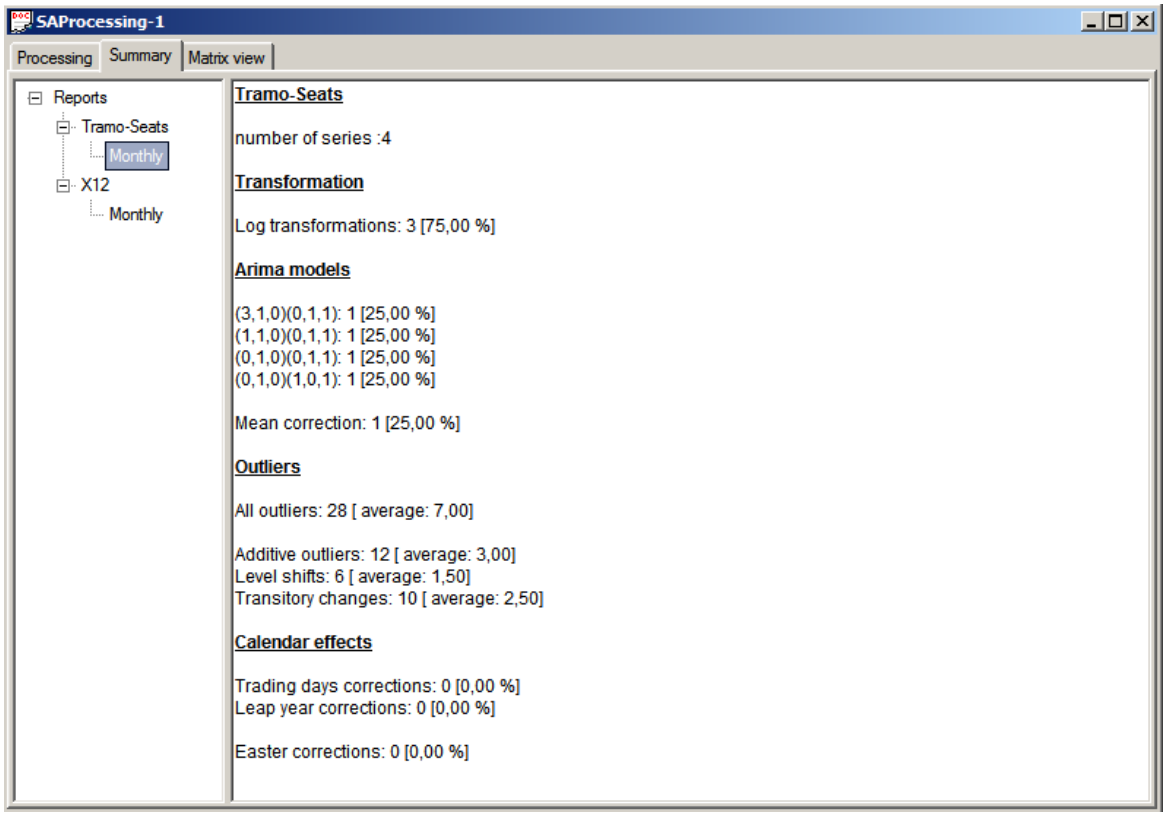
The first panel - *Processing* - gives an overview of the processing of each series and more, especially of the diagnostics computed by Demetra+ on its seasonal adjustment. Some warnings can also be put forward, for short series, non-decomposable models (Seats) or when the differenced series doesn't show seasonal peaks. Information on those warnings is displayed by a tooltip on the series. The user can sort the multi-processing by clicking a column header. The example is shown below:



By clicking on the time series' name a summary of the tests' results is displayed in the right panel. For the description of those tests refer to Chapter 4.3.2.1. At the bottom of the window the graph of final seasonally adjusted series and raw series is displayed.



The *Summary* panel gives general information on the results obtained from each method for each frequency (monthly and quarterly). The example below shows that TramoSeats method has been chosen for four time series. Three of them have been logarithmically transformed. The list of the Arima models shows the model parameters used in time series set. There were 28 outliers detected, the majority of which were additive outliers. Calendar effects weren't detected for any of the time series seasonally adjusted using TramoSeats method.

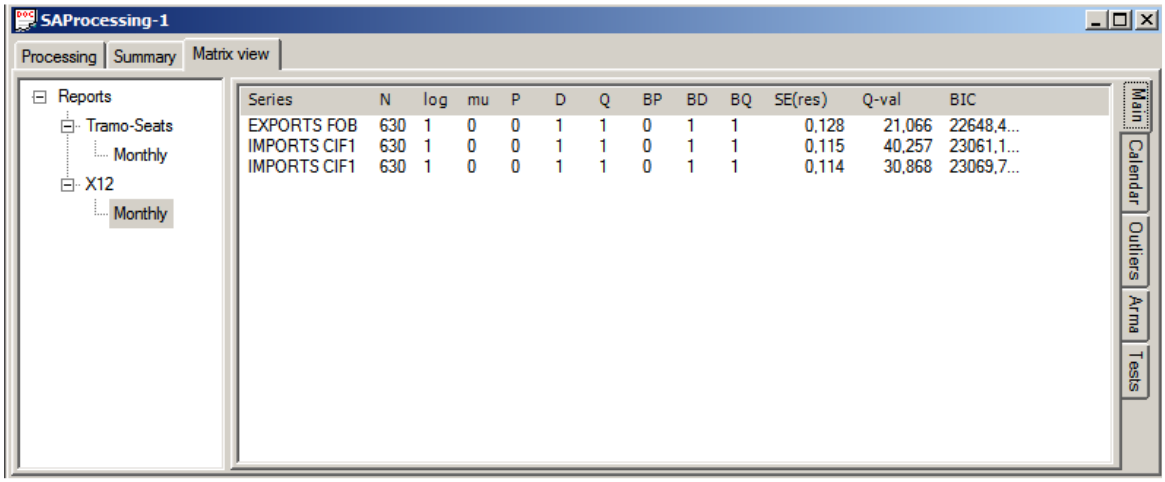


Last section – *Matrix view* panel – provides information similar to the matrix output of TSW (TramoSeats for Windows program).

The summary information is divided into five folds available in the right side of the panel:

- **Main** – contains main statistical properties of the Arima model used in Pre-processing,
- **Calendar** – presents calendar specification results,
- **Outliers** – outlier structure of each series and coefficients of Arima model and their significance levels,
- **Arima** – parameters' values and their t-stat values,
- **Tests** – p-values of different tests computed on the residuals and with other information (annual discrepancies between raw and adjusted data, spectral visual peaks).

Main *Matrix view* panel is presented below:



The matrices can be copied by the usual keys combination (Ctrl+C), and used in other software, like Excel.

4.4.2.2. Multi-processing menu

Menu offers the following options for multi-processing:

Run – runs the defined multi-processing seasonal adjustment,

Update reports – updates the processing after changes in seasonal adjustment specifications,

Refresh – refreshing a processing with new data,

Edit – allows adding new times series to the list (using multi-processing wizard) and pasting previously cut time series again in the list. Last three edit options: **Cut**, **Copy** and **Delete** are active if the time series was marked on the list (see description below),

Priority – indicator that users can use to mark series that require more or less attention. Priorities take values from 0 to 10. Demetra+ computes them automatically, based on the average of the (logged) series. The user can chose the method of computation (log-based or level based).

Save – saves the processing,

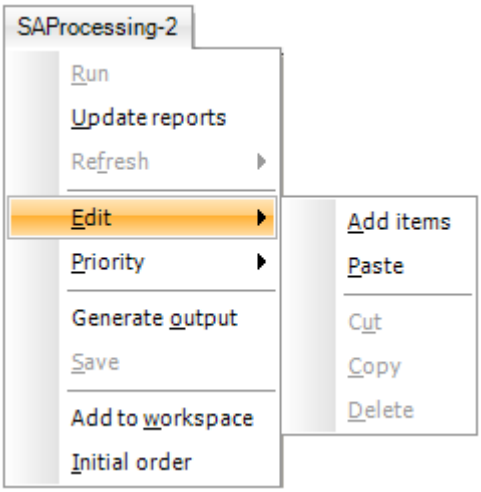
Generate output – offers a set of output formats (txt, XLS, ODBC, CSV, CSV matrix), the choice of the folder that will contain the results (in the example below the file will be saved on disk C:\Documents and Settings…) and the content of the exported file,

Add to workspace – adds the multi-processing to the workspace's tree,

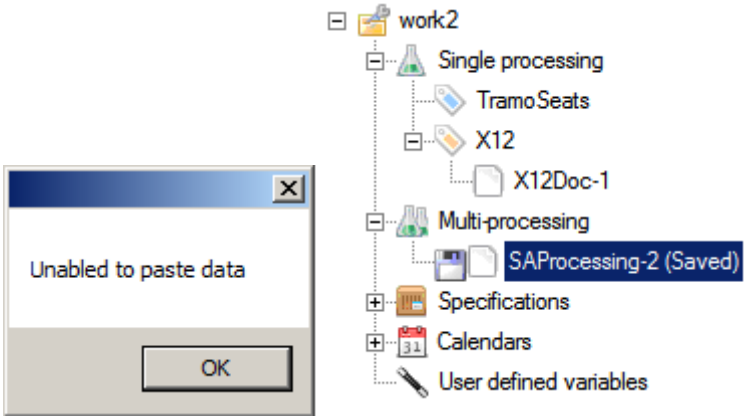
Initial order – displays times series on the list in initial order. The option is useful if the list has been sorted by other column (e.g. by quality or method).

After defining a multi-processing the user should execute the estimation using **Run** option. After that it is possible to **Generate output**. The **Save** option is inactive as soon as the user **Add**s the processing to the Workspace. Once the output was created, the user can save the multiprocessing. The appropriate item will appear in the workspace tree.

The user can add new time series to the multi-processing, using **Edit**->**Add items** option.



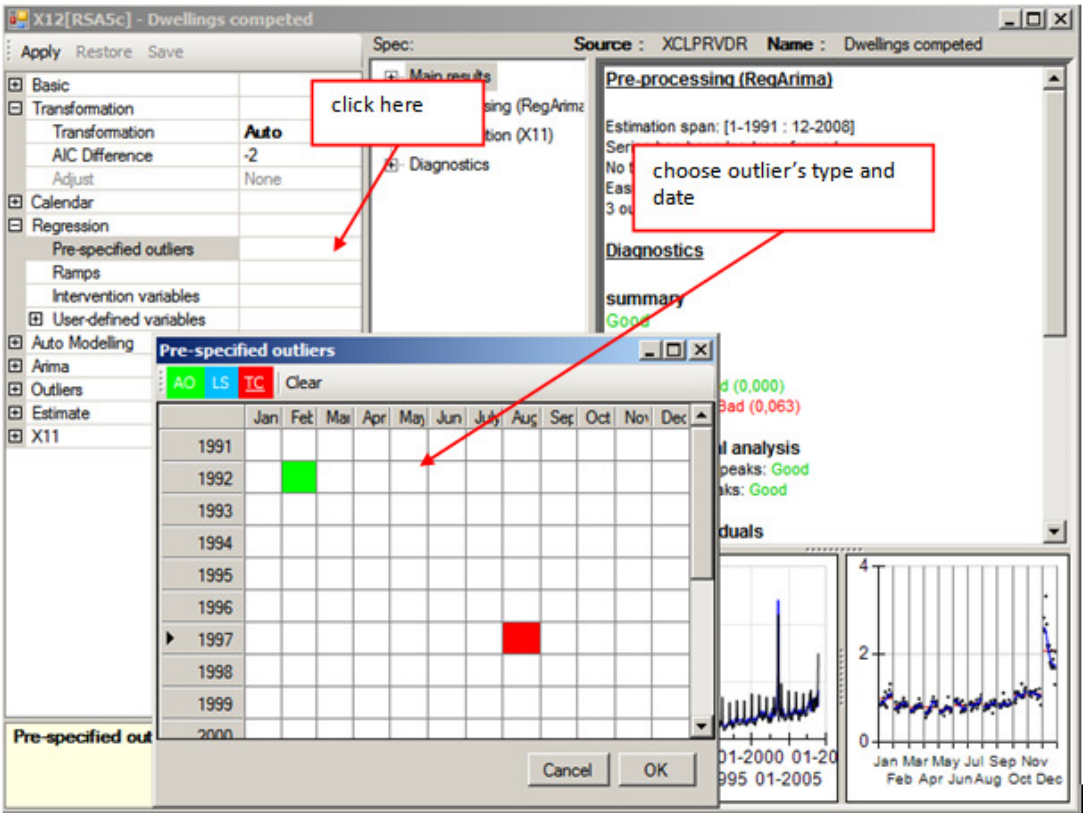
Option **Edit**->**Paste** enables to add to the existing multi processing a new time series directly from external source (e.g. Excel). Before choosing this option the user should copy the time series (data, name of the time series and dates). Otherwise the following message is displayed:



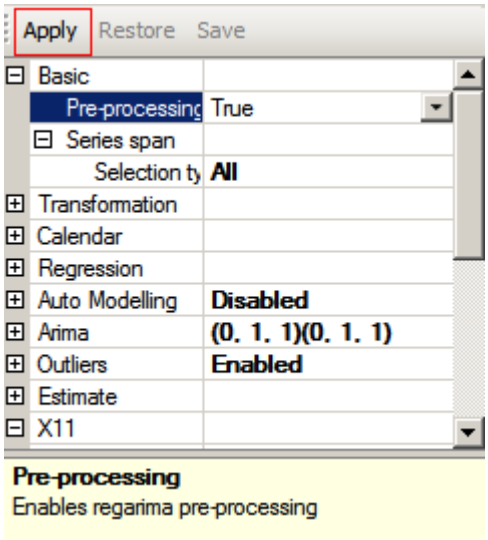
4.4.2.3. Detailed results and modification of the specification

For each time series from multi-processing seasonal adjustment Demetra+ offers the access to the complete description of the results by a double click on the time series' name. This option is available for both *Processing* and *Matrix view* panels. The user is allowed to modify the specification by changing the options in the left part of the window. This option could be useful in case the quality of a specific processing is low and the user wishes to modify some options to get a better result.

As an example, the following panel shows how to change the pre-specified outliers.



When the new options are chosen, the user should click on **Apply** button to launch the seasonal adjustment with modified settings.

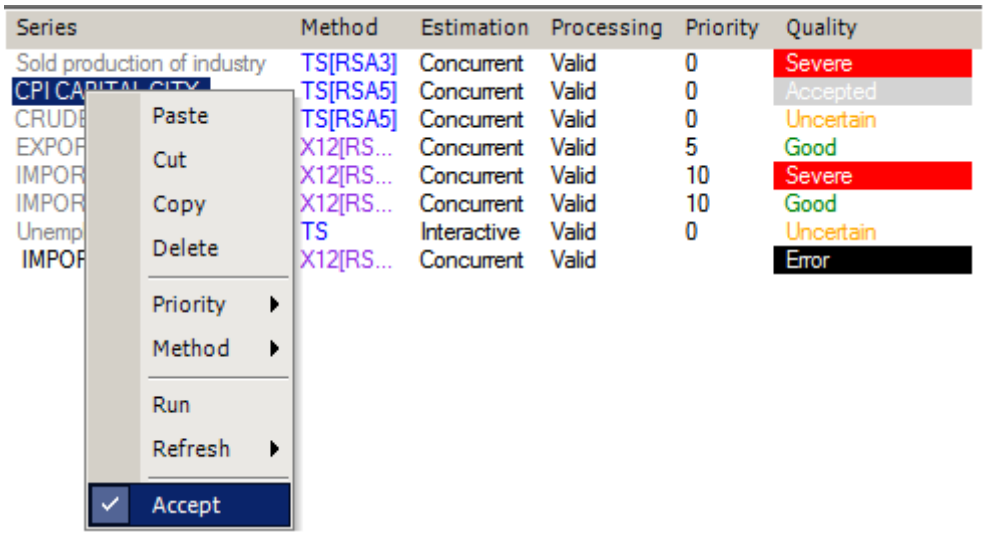


The user can save the new settings and results using **Save** button. The multi-processing will contain then the modified specification for that series. Otherwise, the user can come back to the previous settings using **Restore** button.

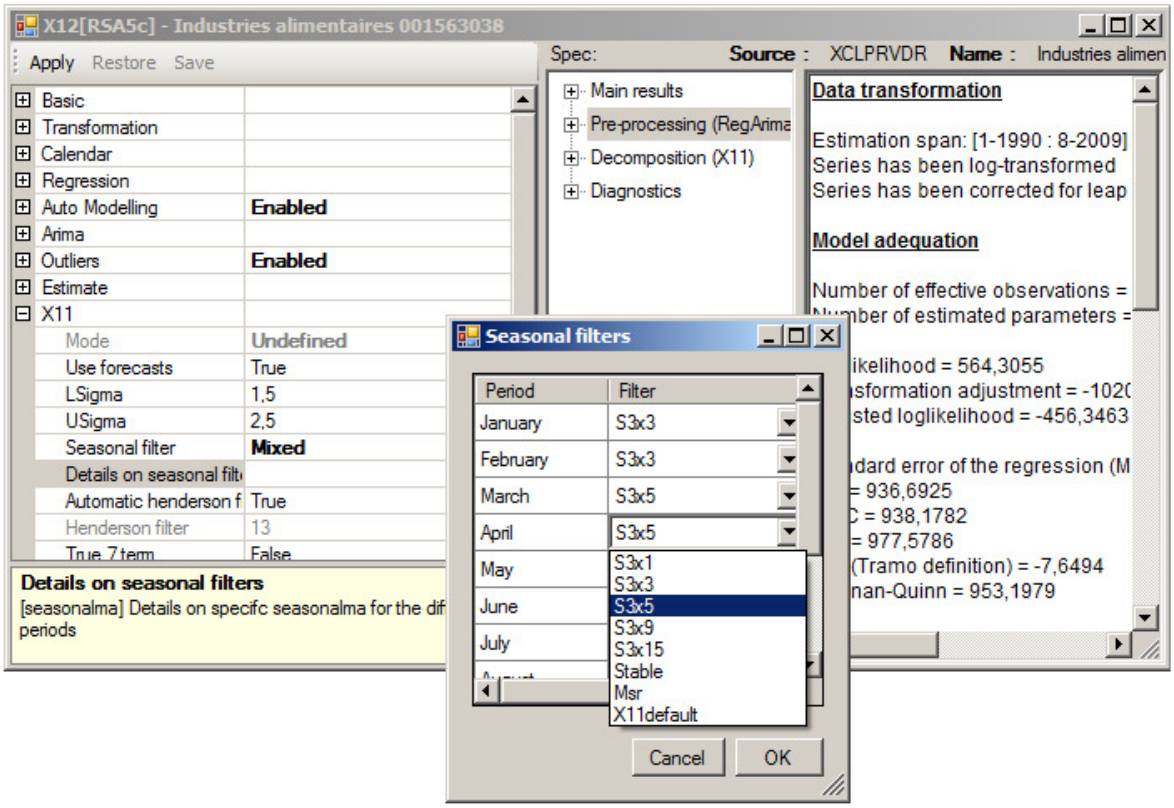
It is not necessary to close the details window to get information on another series; that window is updated by a simple click on another series of the multi-processing view.

It is also possible to create a separate single-processing from a multi-processing document by dragging the corresponding item from the series column to the central panel of Demetra+.

Demetra+ allows the user to accept the models, the quality of which wasn't satisfactory. If the user clicks on the **Accept** option, Demetra+ changes the message displayed in *Quality* column into *Accepted*.

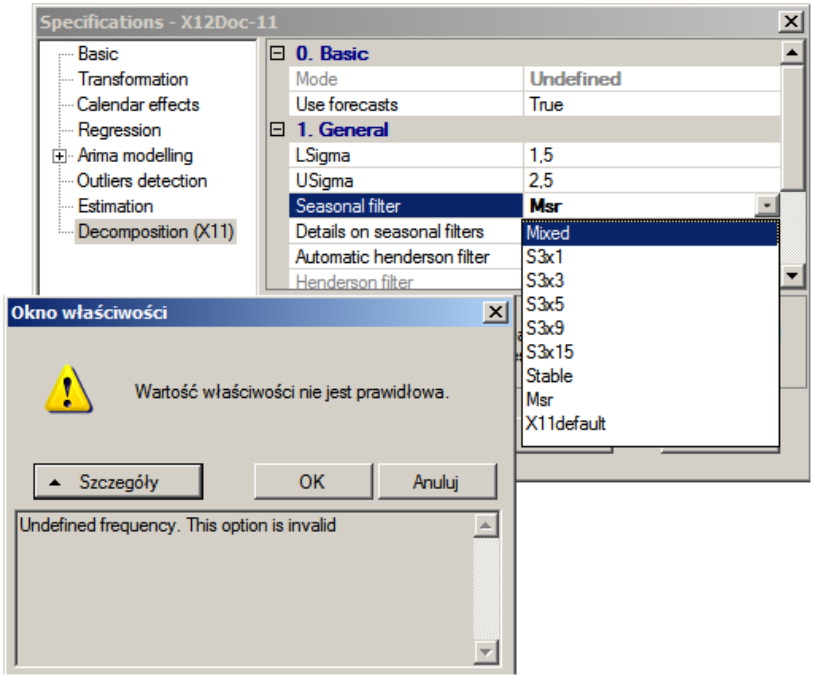


For X12 method it is possible to assign different seasonal filter to each period using option *Mixed* in specification window. It is done in a two-step procedure. First, the time series should be seasonally adjusted using the same seasonal filter for every period. Once seasonal adjustment has been executed, the user is able to modify settings for seasonal filter and change the filter that will be used for estimating seasonal component for each period. To do it **Seasonal filter** should be set to *Mixed*, then the user chooses **Details on seasonal filter**. Finally, the user should specify seasonal filter for each period.



This option could be useful if for some periods seasonal pattern changes faster/slower than for the others. The evaluation can be made using IS ratio chart.

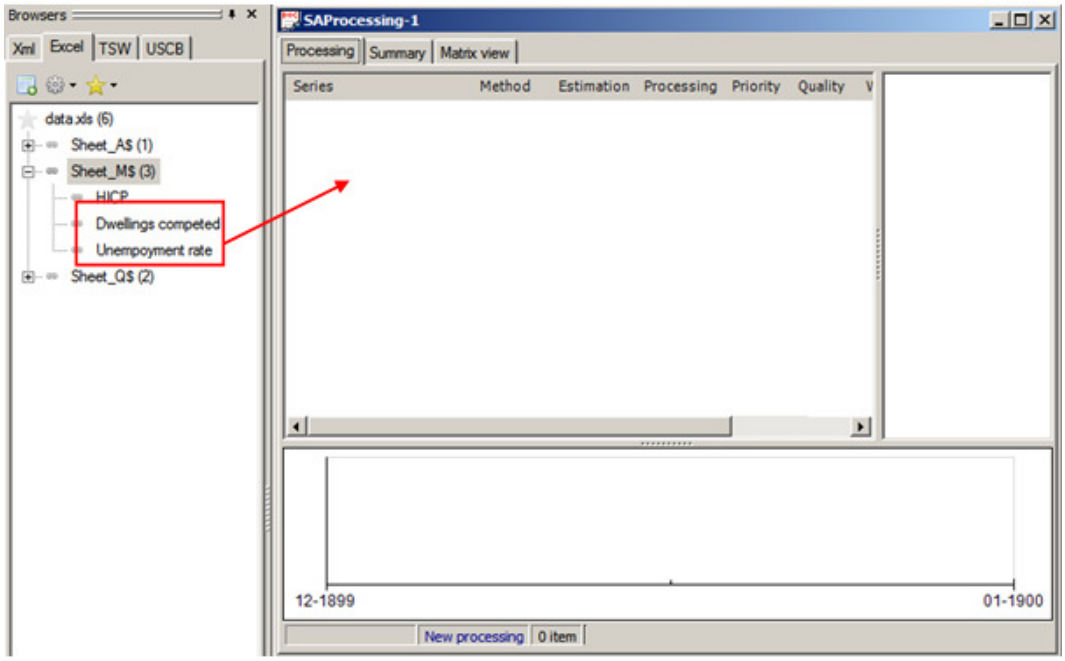
If for the particular time series the multi-processing hasn't been executed yet, option *Mixed* is not available, as Demetra+ needs information about time series frequency. In such case Demetra+ displays the following warning:



The *Mixed* option is unavailable for single-processing.

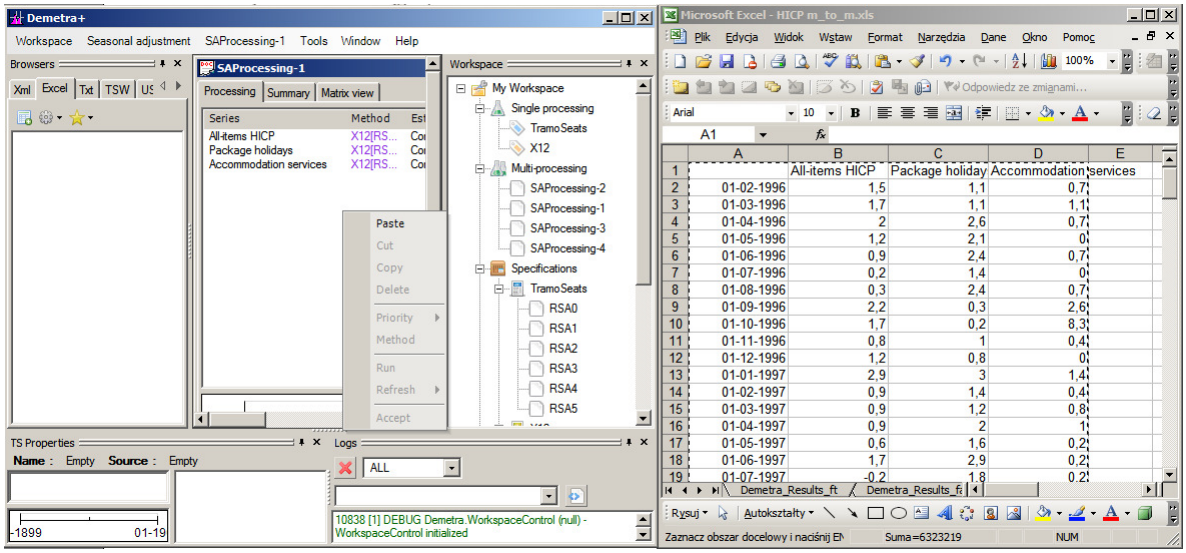
4.4.3. Period-to-period data production

Multi-processing is designed for regular production of the seasonally adjusted data. For this purpose the user should define multi-processing using the data from the browsers, i.e.:



In this case Demetra+ saves the location of the file from which the data come from.

If the variables in multi-processing come directly from external source (e.g. they are copied from Excel and pasted directly into Processing window), it won't be possible to update the processing. Such variables are static, so their location is not saved by Demetra+. Data can be copied from Exel and pasted into Demetra+ multiprocessing window using *Copy/Paste* options. The variables will not be added into the Browser (see picture below).

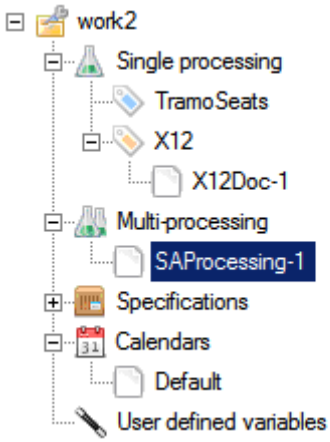


When the multi-processing was created, the user should add it to the workspace and then saved it using the options from multi-processing menu. Then one can use this multi-processing for regular data production (month-to-month or quarter-to-quarter). This process should be conducted in the following way:

1. Update the time series in the external file or source from which the variables come from (e.g. update the file 'data.xls' with the new observations but don't change neither the file's name nor its location).

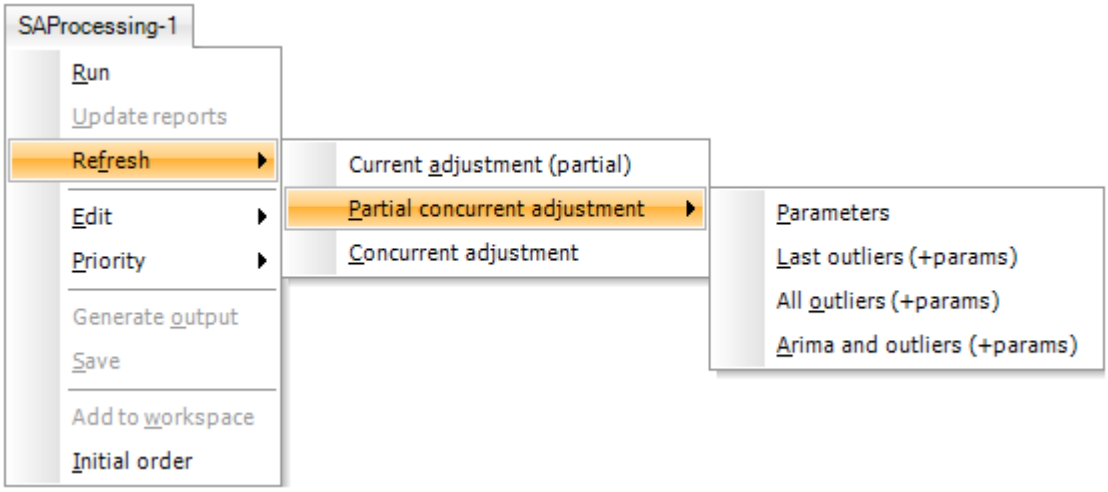
2. Start Demetra+.

3. Chose the multi-processing from the workspace tree by double-clicking on it.

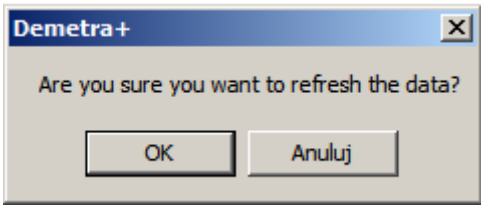


4. Choose in which way you would like to refresh the results[78].

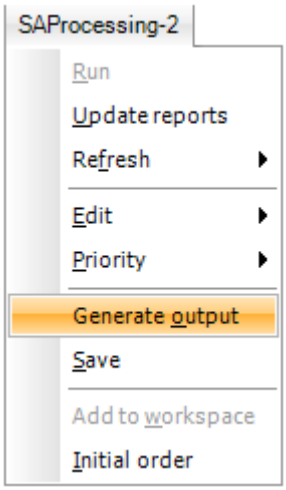
78 For more details see 5.2.



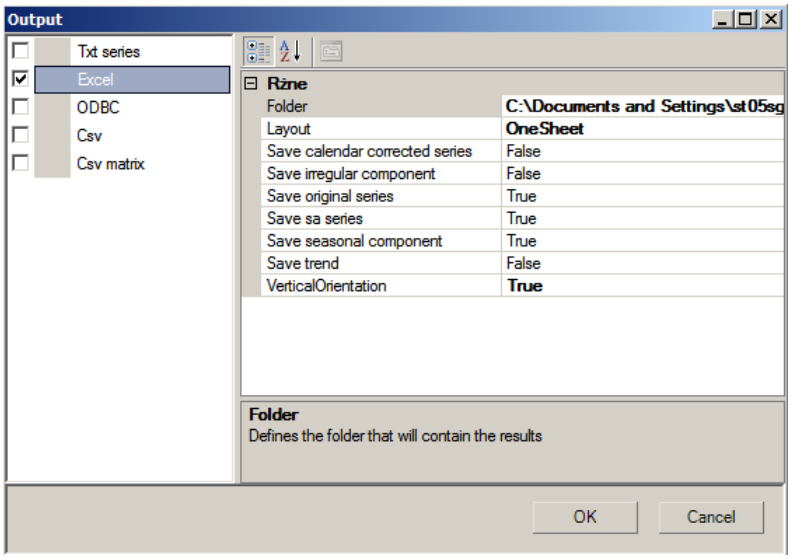
5. Confirm that you want to refresh the data.



6. Choose the option **Generate output** form the menu.



7. Mark the output and click **OK**.



8. Demetra+ creates the file with the output. The old version of the file (e.g. filed created in the previous period) will be replaced by the new version.

Detailed aspects of saving the results in external files are discussed in section 4.4.5.

4.4.4. Further explanations on the refreshing of multi-processing

In majority of cases multi-processing is defined by choosing a rather general specification with numerous "free" options that will be used for the series. This specification is called the "reference specification".

If, for some series, the results are not acceptable, the user will modify the reference specification to achieve a better adjustment (for example by forcing the use of calendar variables). In such a case, the reference for the considered series becomes the specification that has been manually improved.

When a series is processed, its estimation produces a fully identified specification, which is called a "point specification" (in the sense that it corresponds to a unique model). For each series of a multi-processing, the software stores the reference specification and the point specification (in an xml file).

When a user wants to refresh a processing, one has to define for the updated series the specifications (called estimation specification) that will be used. Following the refreshing option, Demetra+ removes some constraints of the point specification, in the limits of the reference specification. For example, when the "All outliers" option is selected, any automatically identified outliers is removed and the automatic outliers identification option of the reference specification is used. If that reference specification doesn't allow automatic outliers identification, the estimation specification will not allow either. Without such an approach, it would be difficult to define exactly the specification that should be used when a processing is refreshed.

The list of the constraints that are removed from the point specifications following the refreshing options is presented below (the second column should be interpreted as a cumulative list).

Option	**Removed constraints**
Current adjustment (partial)	Re-estimation of the coefficients of the regression model
Parameters	Re-estimation of the parameters of the ARIMA-model
Last outliers	Re-estimation of the outliers of the last year only.
All outliers	Re-estimation of all the outliers.
Arima and outliers	Re-estimation of the whole Arima model
Concurrent adjustment	The reference spec is used.

Considering the way Demetra+ works, it is clear that the reference specification should be chosen as general as possible. Otherwise, the refreshing options could be to a large extent useless.

The user can change the specification of a series at any time. What they change manually is actually the reference specification, which is used for the current processing, but also for future re-estimations.

Considering the design of Demetra+, the convenient way for processing many series in a recurrent production context might be as follows:

1. Chosen a large specification that will be applied on the set of series.

2. Modify the specifications that produce bad results. Try to minimize the restrictions you impose on the specification.

3. Save the processing, which is the basis for all the next steps.

4. During one year, refresh for each new period the processing without changing too much the model (typically, use the "Parameters" option). Modify with caution any unacceptable results that could be generated by the new data (new outliers...).

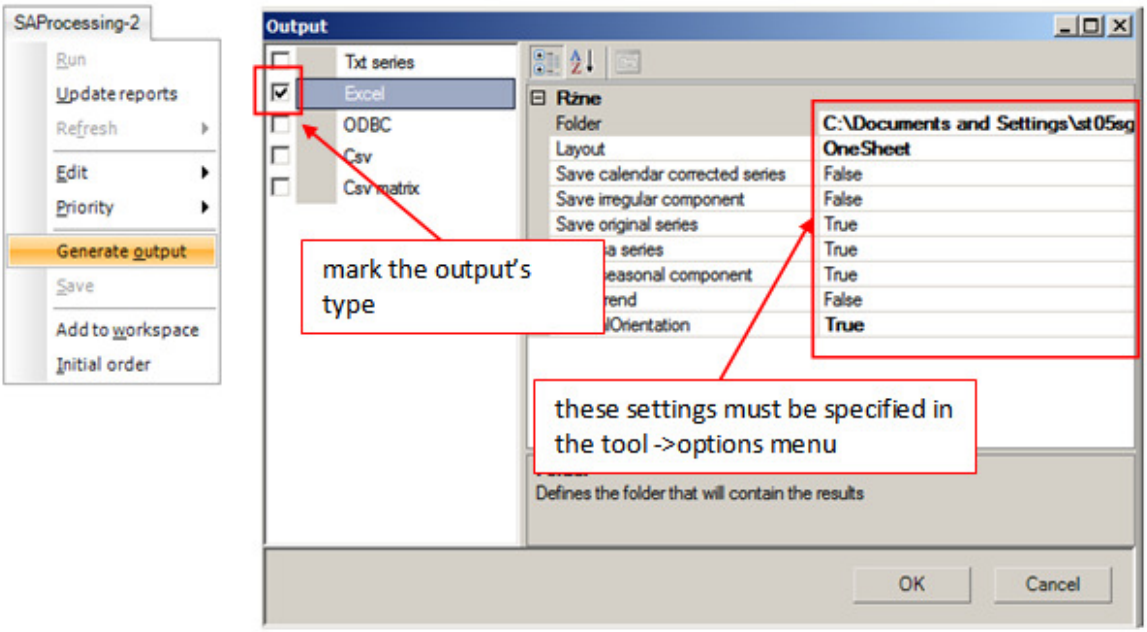
5. After one year, carry out a more serious revision (for instance "All outliers").

4.4.5. Sending the results to external devices

When the multi-processing is created, it is possible to generate several outputs (Excel workbook, csv files...), through the main menu command: *SAProcessingXXX -> Generate output* or (*TSProcessingXXX -> Generate output*). It should be noted that Excel and .csv outputs will be put in the temporary folder if their target folders are not specified.

The user is expected to choose the output format by marking the appropriate box in left-hand side of the *Output* window. The settings which are displayed in the other part of the window come from *Tool -> Options* menu. All changes in those settings should be done in the *Tool ->*

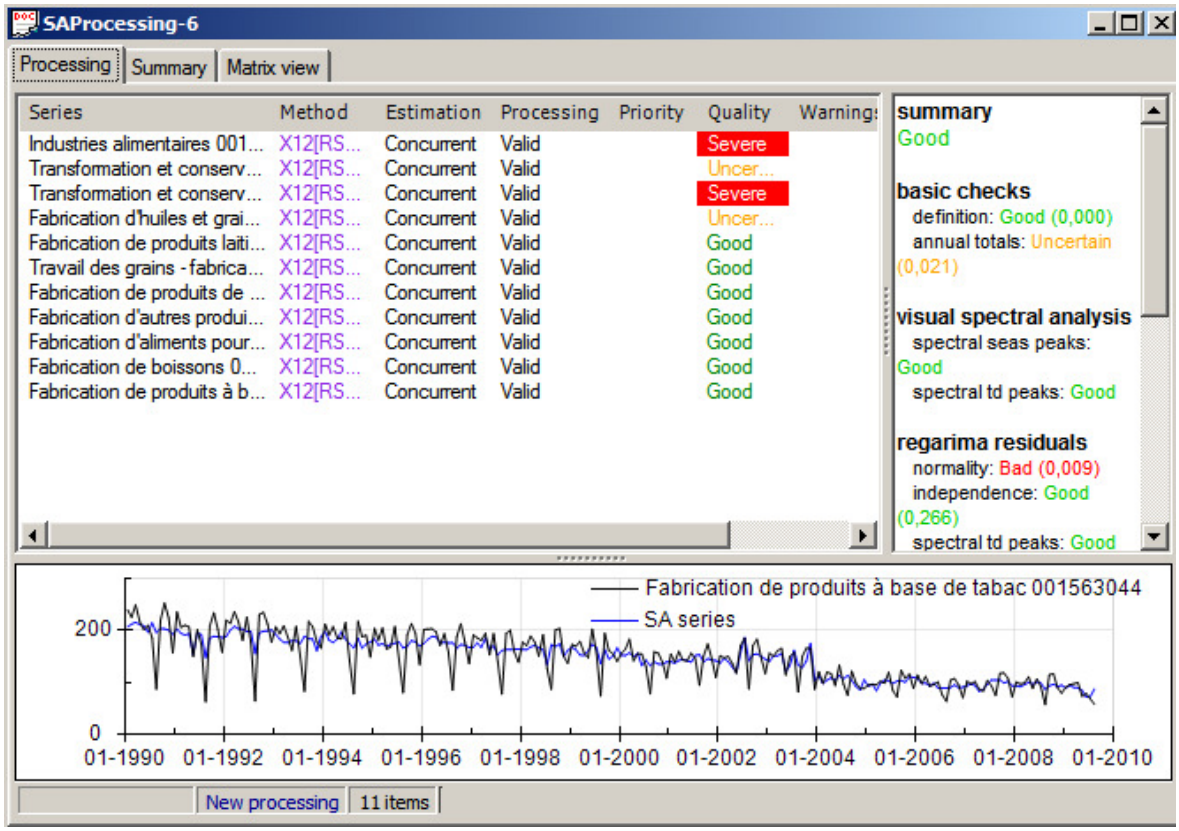
Options menu. If the user changes the settings (e. g. output's folder) in the *SAProcessingXXX -> Generate output* window (or *TSProcessingXXX -> Generate output*), it will not have any effect on the output's content.



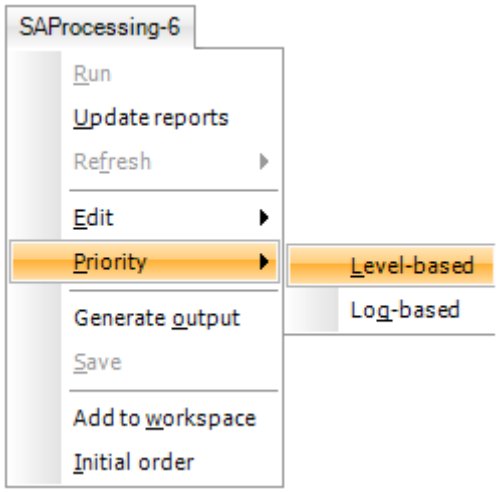
For multi-processing which doesn't belong to a workspace, output files' name is default ("demetra"). If multi-processing is saved in the workspace the multi-processing's name is used.

4.4.6. Assigning priority to the series

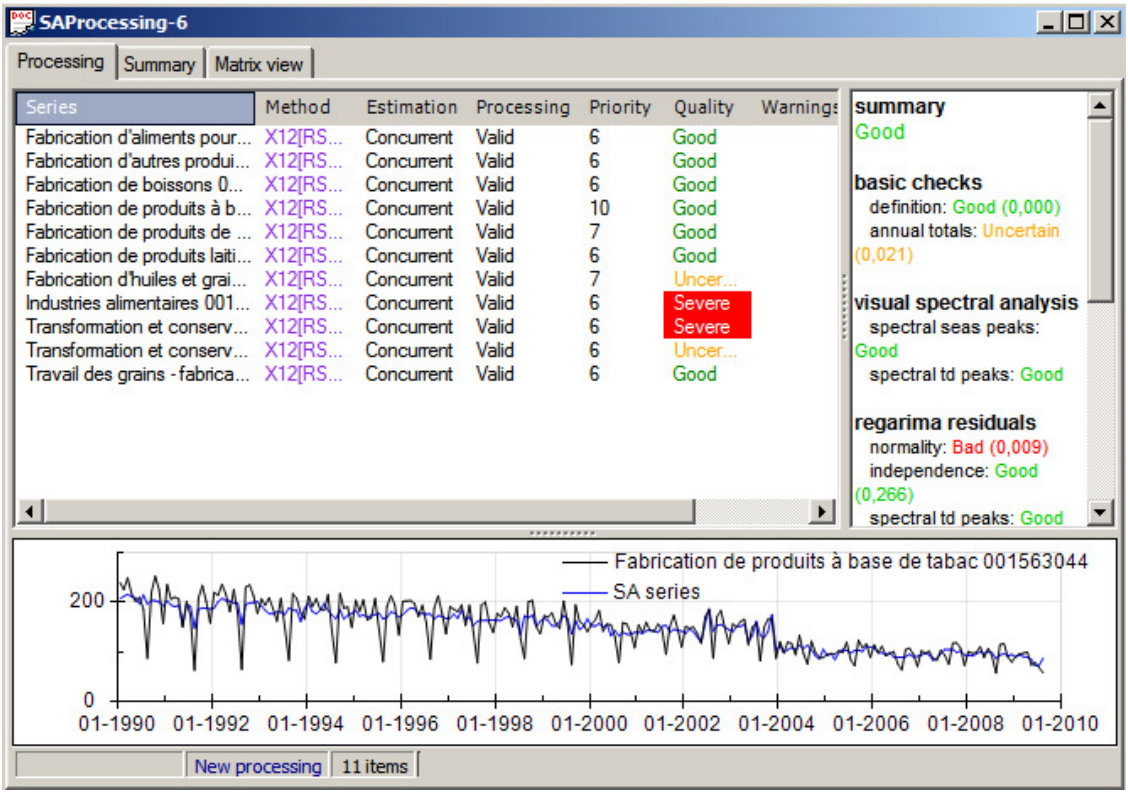
Priorities are simple indicators (from 0 to 10) that users can use to mark series that require more or less attention. The software is able to compute automatically priorities based on the average of the (logged) series. By default priority is not calculated.



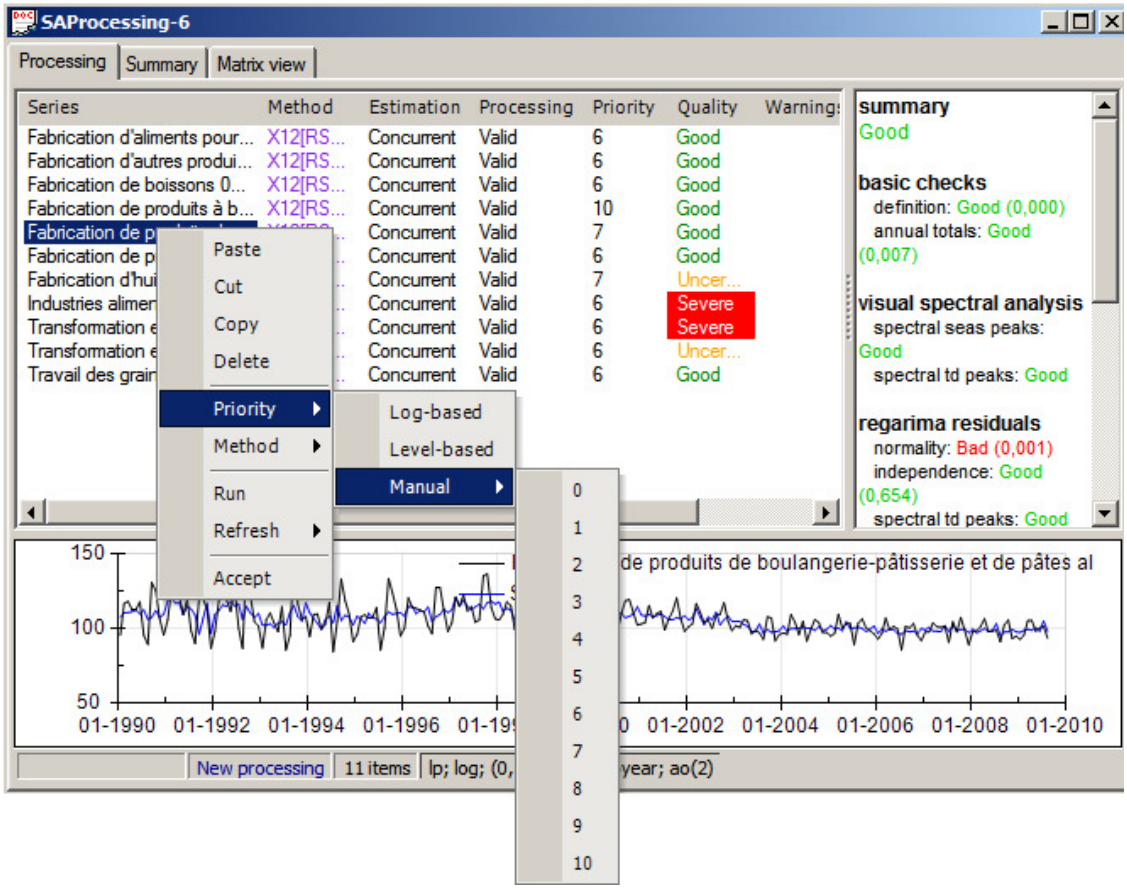
The user can calculate it automatically by choosing one of the **Priority** options available in *SAProcessing* menu.



Priorities will be added to the *SAProcessing* output window.


SAProcessing-6
Processing
Summary
Matrix view
Series
Method
Estimation
Processing
Priority
Quality
Warnings
Fabrication d'aliments pour... X12[RS... Concurrent Valid 6 Good
Fabrication d'autres produi... X12[RS... Concurrent Valid 6 Good
Fabrication de boissons 0... X12[RS... Concurrent Valid 6 Good
Fabrication de produits à b... X12[RS... Concurrent Valid 10 Good
Fabrication de produits de ... X12[RS... Concurrent Valid 7 Good
Fabrication de produits laiti... X12[RS... Concurrent Valid 6 Good
Fabrication d'huiles et grai... X12[RS... Concurrent Valid 7 Uncer...
Industries alimentaires 001... X12[RS... Concurrent Valid 6 Severe
Transformation et conserv... X12[RS... Concurrent Valid 6 Severe
Transformation et conserv... X12[RS... Concurrent Valid 6 Uncer...
Travail des grains - fabrica... X12[RS... Concurrent Valid 6 Good
summary
Good
basic checks
definition: Good (0,000)
annual totals: Uncertain (0,021)
visual spectral analysis
spectral seas peaks: Good
spectral td peaks: Good
regarima residuals
normality: Bad (0,009)
independence: Good (0,266)
spectral td peaks: Good
Fabrication de produits à base de tabac 001563044
SA series
200
0
01-1990 01-1992 01-1994 01-1996 01-1998 01-2000 01-2002 01-2004 01-2006 01-2008 01-2010
New processing
11 items

For particular time series the user can modify *priority* value manually by clicking on the time series name in *SAProcessing* window and choosing *Priority* value from the list (from 1 to 10).



4.5. Additional functions

4.5.1. Changing the specification

The user is able to modify the specification that is currently used for processing and to see immediately the result of changes made.

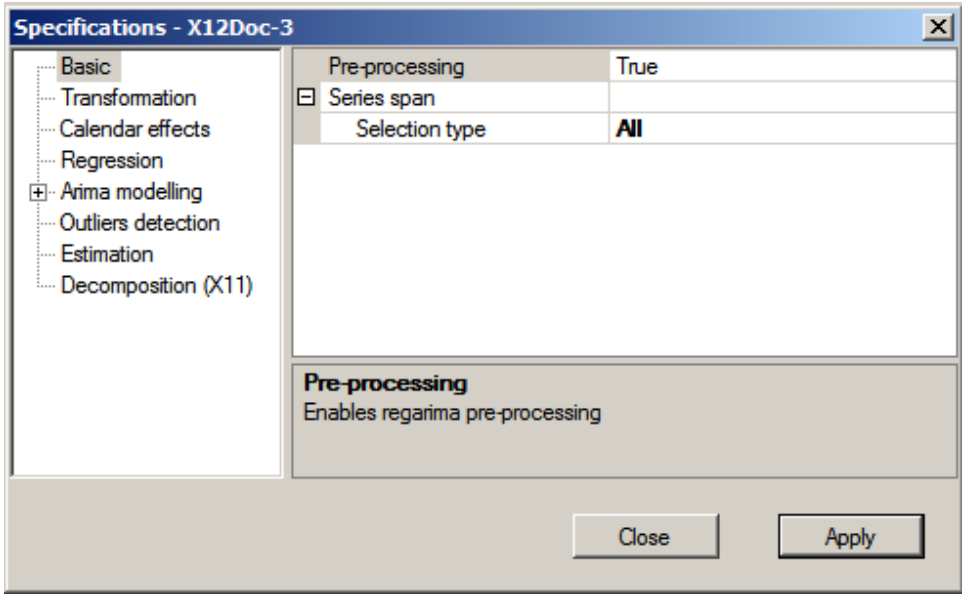
The specification could be edited through the main menu: TramoSeatsDocxxx / X12Docxxx -> Specification... It is possible to edit the specification used to generate the processing (current specification) or the specification that corresponds to the results (result specification).

Current specification is displayed in a non modal dialog box, so the user can change any option and inspect its impact on the results. For a detailed description of the specifications, the user should refer to the 4.1 (X12) or 4.2 (TramoSeats).

The example below refers to X12:

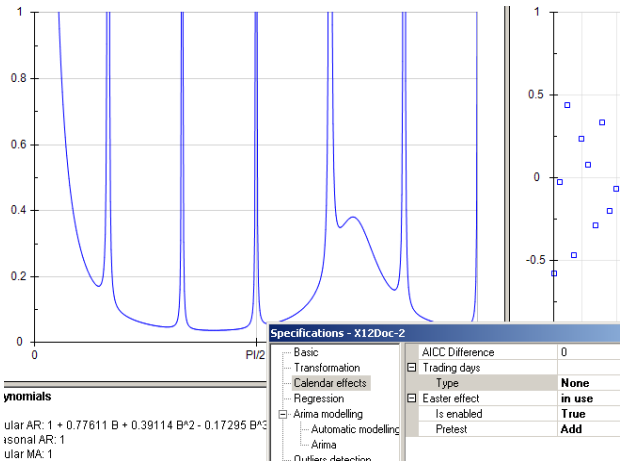
- Activate previously generated output from X12,
- Select from menu X12DocDocxxx-> Specification ->Current Specification,
- Modify the span of the series in the "Basic" panel:
  - Click on the Basic item in the left panel of the specification dialog box,
  - Expand the "series span" node in the right panel,
  - Choose the "excluding" selection type,
  - Write "12" in the "last" node,
- Press the "Apply" button.

The processing is computed on the series without the last 12 observations. A visual comparison of the forecasts of X12 and of the actual figures is displayed on the chart.



This feature is not available from *Workspace* menu. If the user changes the currently used specification by double clicking on its name in *Workspace*, current processing will not be re-calculated.

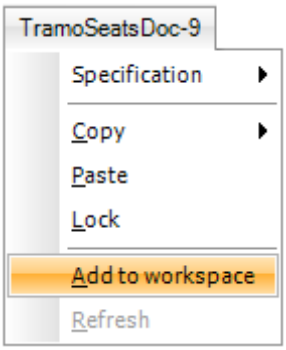
The trading days regression variables can be suppressed by setting the "Trading days -> Type" to "None" in the "Calendar effects" panel of the specification dialog box.



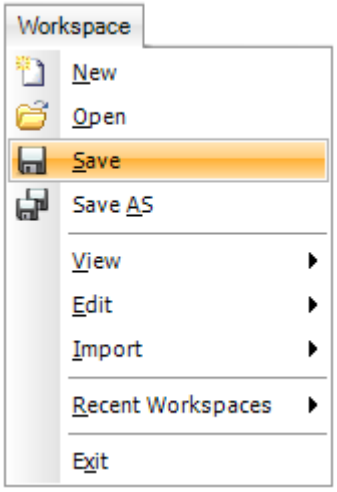
If the option has been used inappropriately used (calendar effect is present, but the user decided not to estimate them) the result will be clearly seen in spectral function computed in pre-processing part.

4.5.2. Saving and refreshing workspaces

By default, single and multi-processing generated through the so-called "short-ways" are not put in the current workspace. To be able to save and to refresh them, the user must first add them to the workspace. That can be done, for instance, through the main menu "SAProcessingXXX -> Add to Workspace".

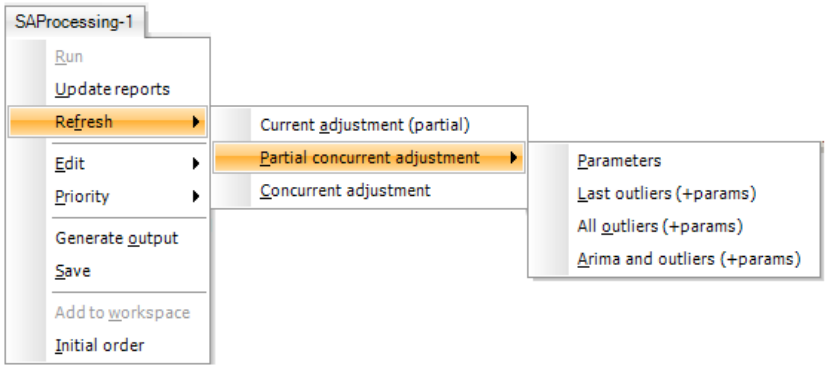


The user still has to save the workspace, using the usual menu command **Save**.



When Demetra+ is re-opened, it will automatically open at the last used workspace. The software also maintains a list of the most recently used workspace, which can be easily accessed.

A saved item of a workspace can be opened by a double click or by its local menu. It is then showed in its previous state. Demetra+ proposes several options to refresh it[79]:



79 For the moment, those options are only available for multi-processing.

Parameters	Only the model parameters are refreshed. The order of the Arima (p,d,q)(P,D,Q) is unchanged
Outliers (+ params)	Outliers and model parameters are re-estimated
Last outliers (+params)	Outliers on the last year and model parameters are re-estimated
Complete	The model is completely re-estimated

When the refresh option has been selected, Demetra+ automatically goes to the suitable time series provider(s) to ask for the updated observations; the new estimations are done on these series (using the previous models, modified by the chosen option).

The example below presents results obtained by applying option "Last outliers (+params)". Outliers are divided into two sections: pre-definied outliers (outliers detected during penultimate execution of the multi-processing) and detected outliers (outliers identified in span $[t_{s-k}, t_{s+n}]$, where s is the number of last available observations during penultimate execution of the multi-processing , n is the number of observations added to the revised time series, k is the frequency of the time series (for quarterly series k =4, for monthly time series k =12).

Pre-specified outliers

Parameter	Value	Std error	T-Stat	P-value
LS[1-1993]	-0,0561	0,0129	-4,36	0,0000
AO[2-2000]	-0,0415	0,0097	-4,26	0,0000
AO[1-2006]	-0,1414	0,0108	-13,10	0,0000
AO[2-2006]	-0,2009	0,0106	-18,91	0,0000
LS[5-2006]	0,1009	0,0130	7,78	0,0000
AO[6-2006]	-0,3588	0,0132	-27,17	0,0000
TC[8-2006]	-0,1506	0,0134	-11,23	0,0000
AO[9-2006]	-0,1482	0,0133	-11,14	0,0000
TC[6-2007]	-0,3771	0,0208	-18,17	0,0000
AO[7-2007]	-0,1081	0,0127	-8,52	0,0000

Detected outliers

Parameter	Value	Std error	T-Stat	P-value
LS[9-2007]	-0,1936	0,0229	-8,46	0,0000
AO[10-2007]	0,1264	0,0254	4,99	0,0000
TC[10-2007]	0,4046	0,0349	11,60	0,0000
LS[12-2007]	0,0621	0,0174	3,57	0,0005
AO[3-2008]	-0,0475	0,0138	-3,44	0,0007
AO[6-2008]	-0,3997	0,0218	-18,35	0,0000
LS[9-2008]	1,9119	0,0824	23,20	0,0000
TC[9-2008]	-2,4138	0,0845	-28,57	0,0000
LS[11-2008]	-0,3133	0,0338	-9,27	0,0000

Annex

1A Definition of the residuals

Because of complexity X12-Arima and TramoSeats methods, their implementation in Demetra+ is not exactly the same as in the software provided, respectively, by U.S. Census Bureau and Bank of Spain. For this reason, there are small differences between original programs and programs implemented in Demetra+. It should be noted that the original solution of TramoSeats and the solution which was implemented in Demetra+ are exactly equivalent when the model doesn't contain regression variables. The same is true for X12 only when the model is a pure AR model. However, in some specific cases (short series, many regression variables and/or missing values...), residuals calculated by Demetra+ could be different that ones obtained from other software in which X12-Arima and TramoSeats methods are implemented (e.g. SAS, TSW, USCB). The definition of the residuals can be found in these references: ANSLEY C. F. (1979), GOMEZ, V. and MARAVALL, A. (1994), LJUNG, G. M. and BOX, G. E. P. (1979), OTTO, M. C., BELL ,W. R. and BURMAN, J. P. (1987). Least squares estimation by means of the QR decomposition

2A Least squares estimation by means of the QR decomposition

We consider the regression model

$$y = X\beta + \varepsilon$$

The least squares problem consists in minimizing the quantity

$$\| X\beta - y \|_2^2$$

Provided that the regression variables are independent, it is possible to find an orthogonal matrix Q, so that

$$Q \cdot X = \begin{pmatrix} R \\ 0 \end{pmatrix}$$ where R is upper triangular.

We have now to minimize

$$\|QX\beta - Qy\|_2^2 = \left\| \begin{pmatrix} R \\ 0 \end{pmatrix} \beta - Qy \right\|_2^2 = \| R\beta - a \|_2^2 + \| b \|_2^2$$

where

$(Qy)_{0\ldots x-1} = a$ and $(Qy)_{x\ldots n-1} = b$.

The minimum of the previous norm is obtained by setting $\beta = R^{-1}a$. In that case, $\| R\beta - a \|_2^2 = 0$

The residuals obtained by that procedure are then b, as defined above.

It should be noted that the QR factorization is not unique, and that the final residuals also depend on the order of the regression variables (the columns of X).

3A Specifications

SA Method	Name	Settings
TramoSeats	RSA0	Level, Airline model
	RSA1	Log/level, outliers detection, Airline model
	RSA2	Log/level, working days, Easter, outliers detection, Airline model
	RSA3	Log/level, outliers detection, automatic model identification
	RSA4	Log/level, working days, Easter, outliers detection, automatic model identification
	RSA5	Log/level, trading days, Easter, outliers detection, automatic model identification
X12	X11	No pre-processing
	RSA1	Log/level, outliers detection, Airline model
	RSA2c	Log/level, working days, Easter, outliers detection, Airline model, pre-adjustment for leap-year if logarithmic transformation has been used
	RSA3	Log/level, outliers detection, automatic model identification
	RSA4c	Log/level, working days, Easter, outliers detection, automatic model identification, pre-adjustment for leap-year if logarithmic transformation has been used
	RSA5	Log/level, trading days, Easter, outliers detection, automatic model identification, pre-adjustment for leap-year if logarithmic transformation has been used

Explanations for settings:

Level – no transformation is performed

Log/level – Demetra+ tests for the log/level specification,

Working days – a pretest is made for the presence of the working day effect by using one parameter specification (working vs. non-working days),

Trading days – a pretest is made for the presence of the trading day effect by using six parameters specification (for working days, the day of week: Monday,...,Fridays specified),

Easter – the program tests for the necessity of a correction for Easter effect in the original series.

Outliers detection – Demetra+ automatically detects all types of outliers including: AO (additive outliers), LS (level shifts), TC (transitory changes) using default critical values.

Airline model – an Airline model (0,1,1)(0,1,1) is estimated.

Automatic model identification – Demetra+ identifies and estimates the best Arima model.

4A Model selection criteria

Model selection criteria are statistical tools for selecting the optimal order of the ARMIA-model. The basic idea behind all these criteria is to obtain much explanatory power (measured by the value of the likelihood function) with only a few parameters. The model selection criteria "penalise" for using many parameters and "rewarsd" for a high value of the likelihood function. Some of the most known information criteria are: Akaike Information Critera (AIC), Corrected Akaike Information Critera (AICC), Hannan-Quinn Information Critera (HannanQuinn) and Schwarz-Bayes information criterion (BIC).

The formulas for model selection criteria are:

$$AIC_N = -2L_N + 2n_p$$

$$AICC_N = -2L_N + 2n_p\left(1 - \frac{n_p + 1}{N}\right)^{-1}$$

$$HannanQuinn_N = -2L_N + 2n_p \log\log N$$

$$BIC_N = -2L_N + n_p \log N$$

Where:

N - number of observations in time series,

n_p - number of estimate parameters,

L_N - loglikelihood function.

For choosing Arima model parameters Tramo uses BIC_N criteria with some constrains aimed at increasing the parsimony and favoring balanced models, i.e., models with similar AR and MA values[80].

For each model selection criteria the model with smaller value is preferred.

80 GOMEZ, V., MARAVALL. A. (1997).

5A TramoSeats method

TramoSeats is a model-based seasonal adjustment method developed by Victor Gomez and Agustin Maravall (Bank of Spain). It consists of two linked programs: Tramo and Seats. Tramo ("Time Series Regression with Arima Noise, Missing Observations, and Outliers") performs estimation, forecasting, and interpolation of regression models with missing observations and Arima errors, in the presence of possibly several types of outliers. Seats ("Signal Extraction in Arima Time Series") performs an Arima-based decomposition of an observed time series into unobserved components. Information about TramoSeats method the user find below derives directly from papers by GÓMEZ, V., and MARAVALL, A.

Pre-processing in Tramo

Program Tramo fits the following regression model to the original time series:

$$z_t = y_t\beta + x_t$$

where:

$\beta = (\beta_1,...\beta_n)$ - vector of regression coefficients,

$y_t = (y_{1t},..., y_{nt})$ - *n* regression variables (trading days variables, leap year effect, outliers, Easter effect, ramps, intervention variables, user-defined variables),

x_t - term that follows the general Arima process: $\phi(B)\delta(B)\nu_t = \theta(B)a_t$,

where:

B is the backshift operator[81],

$\theta_i(B)$, $\varphi_i(B)$ and $\delta_i(B)$ are finite polynomials in B,

a_t is a white-noise variable with constant variance.

Parameters of the ARIMA model are estimated using Hannan-Rissanen algorithm.

Hannan-Rissanen algorithm

Hannan-Rissanen algorithm[82] is a two-step procedure for the selection of appropriate orders for the autoregressive and moving average parameters of the ARIMA model. In a first step a high-

81 Backshift operator B is defined as: $By_t = y_{t-1}$. It is used to denote lagged series.

82 HANNAN, E. J., and RISSANEN, J. (1982), NEWBOLD. D., and BOS, T. (1982).

order $AR(m)$, where $m > \max(p,q)$ model is fitted to the time series X_t. Then the residuals $\hat{a}_k$ from this model are used to provide estimates of innovations in ARMA model ε_t:

$$\varepsilon_t = X_t - \sum_{k=1}^{m} \hat{a}_k X_{t-k}$$

In the second step the parameters p and q of the ARMA model are estimated using a least squares linear regression of X_t onto $X_{t-1},...,X_{t-p},\varepsilon_{t-1},...\varepsilon_{t-q})$ for combination of values p and q. Finally, Hannan-Rissanen algorithm selects a pair of p and q values for which $\log \tilde{\delta}^2_{p,q} + \frac{(p+q)\log T}{T}$ is the smallest.

The advantage of Hannan-Rissanen algorithm is a speed of computation in comparison with exact likelihood estimation.

Signal extraction in Seats

- **Estimation procedure**

The model based signal extraction procedure consist of estimating the seasonally adjusted time series by means of the Wiener-Kolmogorow filter as the Minimum Mean Square Error estimators using UCArima (unobserved component Arima) model. Seats decomposes a series x_t received from Tramo into components x_{it}: $x_t = \sum_{i=1}^{k} x_{it}$.

Each component follows the general Arima model:

$$\delta_i(B)x_{it} = \psi_i(B)a_{it}$$

Where:

i - trend, seasonal, transitory or irregular components[83], respectively,

a_{it} denotes a white-noise variable,

the polynomial $\psi_i(B) = \frac{\theta_i(B)}{\varphi_i(B)}$.

The polynomials $\theta_i(B)$, $\varphi_i(B)$ and $\delta_i(B)$ are of finite order. A white-noise variable is normally, identically and indecently distributed and has a zero-mean and variance of the one-period-ahead

83 For irregular component it is an ARIMA (0,0,0)(0,0,0) model.

forecast error for the observed time series $V(a_i)$. x_t also follows Arima model of the type $\delta_i(B)x_t = \psi(B)a_t$, where a_t is a white-noise variable with variance $V(a)$.

In an unobserved-components model residuals a_t are estimators of the disturbances associated with the unobserved components. These residuals are functions of the innovations (one-step-ahead prediction errors) and are called "pseudo-innovations". Demetra+ uses term "innovations", which should be understand as "pseudo-innovations"[84].

The pseudo-spectrum[85] of x_i is the Fourier transform of $\frac{\psi_i(B)}{\psi_i(F)}$ and is denoted by $g_i(\omega)$,

where ω is a frequency argument and F is a forward operator, for which. $F = B^{-1}$.

For particular realization of $X_T = [x_1, x_2, .., x_T]$ Seats aims to obtain for each component the estimator $\hat{x}_{it|T}$ such that $E\left[\left(x_{it} - \hat{x}_{it}\right) | X_T\right]$ is minimized (it is Minimum Mean Square Error (MMSE) estimator). Under the joint normality assumption $\hat{x}_{it|T}$ is also equal to the conditional expectation $E(s_t \mid X_T)$, so it can be presented as a linear function of the elements in X_T:

$$\hat{x}_{it|T} = ... + \nu_k x_{t-k} + ... + \nu_0 x_t + ... + \nu_k x_{t+k} + ...$$

when $T \to \infty$ the estimator becomes final (historical) estimator. In practice it is achieved for large k. When $T - k < t < T$, $\hat{x}_{it|T}$ yields a preliminary estimator and for $t > T$, a forecast.

The join distribution of the stationary transformation of the components and of their MMSE estimators (i.e., variances, autocorrelations and cross-correlations) is used for model diagnostic.

For each component the estimate $\hat{x}_{it|T}$ is obtained by applying Wiener-Kolmogorow ($\nu_i(B,F)$) filter on x_t:

$$\hat{x}_{it} = \nu_i(B,F)\, x_t,$$

where:

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84 HARVEY, A. C., and KOOPMAN, S. J. (1992).

85 Term spectrum is used for stationary time series, while term pseudo-spectrum is used for non-stationary time series (for no-stationary time series spectrum is not defined). In majority of cases components extracted from original time series are non-stationary. Pseudo-spectrum is defied as: $g_x = \left|\frac{\delta_a}{1 - e^{2i\omega}}\right|^2 = \frac{\delta_2^2}{2(1 - \cos 2\omega)}$ (MARAVALL, A., and PIERCE, D.A. (1986)).

$$\nu(B,F) = \upsilon_0 + \sum_{j=1}^{L} \upsilon_j (B^j + F^j),$$

which is symmetric.

In practice, L typically expands between 3 and 5 years. Hence, when $T > 2L+1$, where T is the last observed period, final estimators can be assumed for the central observations of the series[86]. Symmetric and centered filter allow to avoid phase effect. The filter can be expand in the following way:

$$\hat{x}_{it} = \upsilon_k x_{t-k} + ... + \upsilon_1 x_{t-1} + \upsilon_0 x_t + \upsilon_1 x_{t+1} + ... + \upsilon_k x_{t-k}$$

When $T < t+k$, observations at the end of time series, that are necessary to calculate $\hat{x}_{it}$ are not available yet, so the filter cannot be applied. Because of that needed future values are replaced by their optimal forecast from ARIMA model on x_t. The estimator that uses such forecasted values is called preliminary estimator. As the forecasts are linear functions of present and past observations of x_t, the preliminary estimator of $\hat{x}_{it}$ obtained with the forecasts will be a truncated filter applied to the x_t. This truncated filter will not be centered, nor symmetric. As a result, the phase effect occurs[87].

- **Wiener-Kolmogorow filter and ACGF function**

Wiener-Kolmogorow[88] filter shows the weights with which the each component's innovation contribute to the estimator $\hat{x}_{it|T}$. These weights provide the moving average expressions for the revisions.

For the two component model (s_t - seasonal component, n_t-non-seasonal component) in the frequency domain Wiener-Kolmogorow filter ($\nu(B,F)$) that provide the final estimator of $s(t)$ is expressed as the ratio of the $s(t)$ and $x(t)$ pseudospectra:

$$\tilde{\nu}(\omega) = \frac{g_s(\omega)}{g_x(\omega)}$$

The spectrum of the estimator of the seasonal component is expressed as:

86 MARAVALL, (1998).

87 KAISER, R. and MARAVALL, A. (2000).

88 Description based on MARAVALL, (2011).

$$g_{s}^{\wedge}(\omega) = \left[\frac{g_s(\omega)}{g_x(\omega)}\right]^2 g_x(\omega).$$

From this equation it is clear that the squared gain of the filter determines how the variance of the series contributes to the variance of the seasonal component for the different frequencies.

In time domain the ratio of pseudo-spectra are replaced by the ratio of autocovariance generating function (ACGF) [89]:

$$\nu(B,F) = k_s \frac{\gamma_s(B,F)}{\gamma(B,F)},$$

where:

$\gamma_s(B,F) = \frac{\theta_s(B)\theta_s(F)}{\varphi_s(B)\delta_s(B)\varphi_s(F)\delta_s(F)} V(a_s)$ is ACGF of s_t,

$\gamma(B,F) = \frac{\theta(B)\theta(F)}{\varphi(B)\delta(B)\varphi(F)\delta(F)} V(a)$ is ACGF of x_t,

$k_s = \frac{V(a_s)}{V(a)}$

Thus, Weiner-Kolmogorow filter for seasonal component s_t is expressed as:

$$\nu_s(B,F) = k_s \frac{\theta_s(B)\theta_s(F)\varphi_n(B)\varphi_n(F)}{\theta(B)\theta(F)},$$

Letting $f_*(\lambda)$ denote a pseudo-spectrum. One can define[90]:

---

89 The ACGF is well defined for the stationary time series, i.e. ACGF of $\delta_s(B)s_t$ is $\frac{\theta_s(B)\theta_s(F)}{\varphi_s(B)\varphi_s(F)} V(a_s)$; $\delta_s(B)$ and $\delta(B)$ contain differencing operators that make, respectively, s_t and x_t stationary. Thus, for s_t the pseudo-ACGF is calculated as: $\frac{\theta_s(B)\theta_s(F)}{\delta_s(B)\delta_s(F)\varphi_s(B)\varphi_s(F)} V(a_s)$.

90 MARAVALL, A. and CANETE, D. (2011).

$\hat{f}_n(\lambda) = \left[\frac{f_n(\lambda)}{f_x(\lambda)}\right]^2$, were: $f_x(\lambda) = \left[\frac{f_n(\lambda)}{f_x(\lambda)}\right]^2 f_n(\lambda)$, so $f_x(\lambda) < f_n(\lambda)$

and:

$\hat{f}_s(\lambda) = \left[\frac{f_s(\lambda)}{f_x(\lambda)}\right]^2 f_s(\lambda)$, so $\hat{f}_s(\lambda) < f_s(\lambda)$

Then the expression: $f_x(\lambda) - \left[\hat{f}_n(\lambda) + \hat{f}_s(\lambda)\right]$ is the cross -spectrum (in time domain it is cross-covariance function). As $f_x(\lambda) - \left[\hat{f}_n(\lambda) + \hat{f}_s(\lambda)\right] > 0$, MMSE yields correlated estimators. Nevertheless, cross-correlations estimated by TramoSeats tend to zero as cross-covariancies between component's estimators and estimators are finite when at least one non-stationary component exists.

The ACGF for the stationary transformation of component $\delta_s(B)s_t$ that follows the model $\delta_s(B)s_t = \psi_s(B)a_{st}$ is $\gamma_s = \frac{\theta_s(B)\theta_s(F)}{\delta_s(B)\delta_s(F)}V(a_s)$. The final, MMSE estimator of seasonal component, follows the model $\hat{s}_t = \nu(B,F)x_t$. As $x_t = \frac{\theta(B)}{\varphi(B)\delta(B)}a_t$ and $\nu_s(B,F) = k_s\frac{\theta_s(B)\theta_s(F)\varphi_n(B)\varphi_n(F)}{\theta(B)\theta(F)}$, the final estimator can be expressed in terms of the innovations in original series[91]:

$\delta_s(B)\hat{s}_t = k_s\frac{\theta_s(B)\theta_s(F)\varphi_n(B)\varphi_n(F)}{\varphi_s(B)\theta(F)}a_t$.

ACGF of theoretical final estimator is calculated as:

$\tilde{\gamma}_s = \frac{\alpha(B)\alpha(F)}{\beta(B)\beta(F)}\tilde{k}_s$,

where:

$\alpha(B) = \theta_s(B)^2\varphi_n(B)\delta_n(B)$

$\alpha(F) = \theta_s(F)^2\varphi_n(F)\delta_n(F)$

$\beta(B) = \varphi_s(B)\theta(B)$

$\beta(F) = \varphi_s(F)\theta(F)$

91 D. CANETE, A. MARAVALL, (2011).

$$\tilde{k}_s = \frac{V(a_s)^2}{V(a)}$$

ACGF can be also presented as a following function:

$$\gamma_0 + \sum_{j=1}^{\infty} \gamma_j (B^j + F^j),$$

where:

γ_j - correlation between observations separated by lag j.

The spectrum can be obtained from ACGF function by applying Fourier Transform[92].

- **PsiE-weights**

Estimator of seasonal factor is calculated as:

$$\hat{s}_t = \nu_s(B,F)\, x_t$$

By replacing $x_t = \frac{\theta(B)}{\delta(B)} a_t$, seasonal factor can be expressed as:

$$\hat{s}_t = \nu_s(B,F) \frac{\theta(B)}{\delta(B)} a_t .$$

Let $\xi_s(B,F) = \nu_s(B,F) \frac{\theta(B)}{\delta(B)}$

$$\xi_s(B,F) = ... + \xi_j B^j + ... + \xi_1 B + \xi_0 + \xi_{-1} F + ... + \xi_{-j} F^j + ..$$

which are called PsiE-weights. As it can be seen, the PsiE-weights are obtained from the Wiener-Kolmogorow filter by multiplying by $\frac{\theta(B)}{\delta(B)}$.

Hence, PsiE-weights can be divided into two components: first one: $... + \xi_j B^j + ... + \xi_1 B + \xi_0$ applies to prior and concurrent innovations, second one: $... + \xi_j B^j + ... + \xi_1 B + \xi_0$ applies to

92 MARAVALL, A. (2008).

future (i.e. posterior to t innovations. ξ_j determines contribution of a_{t-j} to $\hat{s}_t$ while ξ_{-j} determines contribution of a_{t+j} to $\hat{s}_t$.

For $j \geq 0$ PsiE-weight j determines contribution of total innovation from period $T-j$ to component estimator $\hat{x}_{it}$. For $j < 0$ PsiE-weight j determines contribution of total innovation from period $T+j$ to component estimator $\hat{x}_{it}$. It is assumed that $T > 2L+1$.

Hence, estimator of the seasonal component can be expressed as $\hat{s}_{it} = \xi_i(B)^- a_{it} + \xi_i(F)^+ a_{it+1}$.

$\xi_i(B)^- a_{it}$ is an effect of starting conditions, present and past innovations in series while $\xi_i(F)^+ a_{it+1}$ is an effect of future innovations which is a zero-mean, convergent, one-sided (stationary) MA process.

- **Errors analysis**

For each i-th component total error in the preliminary estimator $d_{it|t+k}$ is expressed as:

$d_{it|t+k} = m_{it} - \hat{m}_{it|t+k}$,

where:

m_{it} - i-th component,

$\hat{m}_{it|t+k}$ - the estimator of m_{it} when the last observation is x_{t+k} (x_t is a time series),

$d_{it|t+k}$ can be presented as the sum of the final estimation error (e_t) and the revision error ($r_{t|t+k}$) :

$$d_{t|t+k} = m_{it} - \hat{m}_{it|t+k} = (x_{it} - \hat{x}_{it}) + (\hat{x}_{it} - \hat{x}_{it|t+k}) = e_{it} + r_{it|t+k}$$

The final estimation error (e_{it}) and the revision error ($r_{it|t+k}$) are assumed orthogonal[93].

93 MARAVALL, A. (2000).

6A Initial values for Arima model estimation

The default choice of initial parameter values in X12 is 0.1 for all AR and MA parameters. For majority of time series this default value seems to be appropriate. Introducing better initial values (as might be obtained, e.g., by first fitting the model using conditional likelihood) could slightly speed up convergence. Users are allowed to introduce manually initial values for AR and MA parameters that are then used to start the iterative likelihood maximization. This is rarely necessary, and in general not recommended. A possible exception to this occurs if initial estimates that are likely to be extremely accurate are already available, such as when one is re-estimating a model with a small amount of new data added to a time series. However, the main reason for specifying initial parameter values is to deal with convergence problems that may arise in difficult estimation situations[94].

7A Cancellation of AR and MA factors

A cancellation problem consists in cancelling some factors on both sides of the Arima model. This problem concerns mixed Arima $(P,D,Q)(BP,BP,BQ)$ models (i.e., $p>0$ and $q>0$ or $P>0$ and $Q>0$). For example, cancellation problem occurs with Arima (1,1) model, $(1-\phi B)z_t=(1-\theta B)a_t$ when $\phi=\theta$ as then model is simply form: $z_t=a_t$. such model causes problems with convergence of the nonlinear estimation. For this reason X12 and TramoSeats programs checks cancellation problem by computing zeros of the AR and MA polynomials. As cancellation does not need to be exact, the cancellation limit can be provided by the user[95].

8A X12 tables

Part A – Preliminary Estimation of Extreme Values and Calendar Effects

Table A1 – Original series

Table A1a – Forecast of Original Series

Table A2 – Leap year effect

Table A6 – Trading Day effect (1 or 6 variables)

Table A7 – Easter effect

Table A8 – Total Outlier Effect

Table A8ao – Additive outlier effect

Table A8ls – Level shift effect

94 Description based on 'X-12-ARIMA Reference Manual', (2007).

95 Description taken from 'X-12-ARIMA Reference Manual', (2007).

Table A8tc – Transitory effect

Part B – Preliminary Estimation of Time Series Components

Table B1 – Original series

Table B2 – Unmodified Trend-Cycle

Table B3 – Unmodified Seasonal-Irregular Component

Table B4 – Replacement Values for Extreme S-I Values

Table B5 – Seasonal Component

Table B6 – Seasonally Adjusted Series

Table B7 – Trend-Cycle

Table B8 – Unmodified Seasonal-Irregular Component

Table B9 – Replacement Values for Extreme S-I Values

Table B10 - Seasonal Component

Table B11 – Seasonally Adjusted Series

Table B13 – Irregular Component

Table B17 – Preliminary Weights for the Irregular

Table B20 – Adjustment Values for Extreme Irregulars

Part C – Final Estimation of Extreme Values And Calendar Effects

Table C1 – Modified Raw Series

Table C2 –Trend-Cycle

Table C4 – Modified S-I

Table C5 – Seasonal Component

Table C6 – Seasonally Adjusted Series

Table C7 – Trend-Cycle

Table C9 – S-I Component

Table C10 – Seasonal Component

Table C11 – Seasonally Adjusted Series

Table C13 – Irregular Component

Table C20 – Adjustment Values for Extreme Irregulars

Part D – Final Estimation of the Different Components

Table D1 – Modified Raw Series

Table D2 –Trend-Cycle

Table D4 – Modified S-I

Table D5 – Seasonal Component

Table D6 – Seasonally Adjusted Series

Table D7 – Trend-Cycle

Table D8 – Unmodified S-I Component

Table D9 – Replacement Values for Extreme S-I Values

Table D10 – Final Seasonal Factors

Table D10A – Forecast of Final Seasonal Factors

Table D11 – Final Seasonally Adjusted Series

Table D11A – Final Seasonally Adjusted Series with Revised Annual Totals

Table D12 – Final Trend-Cycle

Table D12A – Forecast of Final Trend Component

Table D13 – Final Irregular Component

Table D13U – Irregular component (excluded outlier effects)

Table D16 – Seasonal and Calendar Effects

Table D16A – Forecast of Seasonal and Calendar Component

Table D18 – Combined Calendar Effects Factors

Part E – Components Modified for Large Extreme Values

Table E1 – Raw Series Modified for Large Extreme Values

Table D2 – SA Series Modified for Large Extreme Values

Table E3 – Final Irregular Component Adjusted for Large Extreme Values

Table E11 – Robust Estimation of the Final SA Series

9A Spectral analysis

Definition of the periodogram

The periodogram of the series $\{y_t\}_{1<t\leq n}$ is computed as follows:

1. The y_t is standardized

$$\bar{y} = \frac{\sum_{t=1}^{t\leq n} y_t}{n}$$

$$\hat{\delta}_y^2 = \frac{\sum_{t=1}^{t\leq n} (y_t - \bar{y})^2}{n}$$

$$z_t = \frac{(y_t - \bar{y})}{\hat{\delta}_y}$$

2. The periodogram is computed on the standardized z_t.

$$I_{n,z}(\lambda) = \frac{2}{n}(C_{n,z}^2(\lambda) + S_{n,z}^2(\lambda))$$

where

$$C_{n,z}(\lambda) = \sum_{t=1}^{n} \cos(\lambda t) z_t \text{ and } S_{n,z}(\lambda) = \sum_{t=1}^{n} \sin(\lambda t) z_t$$

Periodogram at the Fourier frequencies

The Fourier frequencies are defined by:

$$\lambda_j = \frac{2\pi j}{n}, 0 < j \leq \left[\frac{n}{2}\right]$$

If the z_t are iid $N(0,1)$, it is easy to see that the corresponding quantities. $I_{n,z}(\lambda_j)$ are iid $\chi^2(2)$.

We have indeed that

$$\sum_{t=1}^{n} e^{it(\lambda_j-\lambda_k)} = \begin{cases} n \; if \;\; j=k \\ 0 \; if \;\; j \neq k \end{cases}$$

and

$$\sum_{t=1}^{n} \cos^2(\lambda_j t) = \sum_{t=1}^{n} \sin^2(\lambda_j t) = \frac{n}{2} ,,$$

so that $\sqrt{\frac{2}{n}} C_{n,z}(\lambda_j)$ and $\sqrt{\frac{2}{n}} S_{n,z}(\lambda_k)$ are uncorrelated $N(0,1)$ random variables.

Test on the periodogram

Under the hypothesis that z_t is a Gaussian white noise, and considering subset J of Fourier frequencies, we have:

$$\Pr\left\{\max_{j\in J} I_{n,z}(\lambda_j) \leq \alpha\right\} = \left[1 - e^{-\frac{\alpha}{2}}\right]^{\#J}$$

If we consider the sets of Fourier frequencies on or near the trading days frequencies on one side and on or near the seasonal frequencies on the other side, we can use the above formula as rough test regarding the absence of trading days/seasonal effects in the considered series.

The software considers the Fourier frequencies which are on or near the following frequencies (the nearest is chosen, or two if they are equidistant):

Annual frequency	Seasonal	Trading days
12	2π/12, 4π/12, 6π/12, 8π/12, 12π/12	d, 2.714
6	2π/6, 4π/6	d
4	2π/4	d, 1.292, 1.850, 2.128
3	-	d
2	-	d

where d is computed as follows:

if s is the frequency of the series,

$$n = \frac{365.25}{s}$$

$$d = \frac{2\pi}{7} \cdot \text{ (n modulo 7)}$$

Autoregressive spectrum

Autoregressive spectrum estimator is defined as follows[96]:

$$\hat{s}(\lambda) = 10 \log_{10} \left\{ \frac{\hat{\delta}_m^2}{2\pi \left| 1 - \sum_{j=1}^{m} \hat{\phi}_j e^{i2\pi j\lambda} \right|^2} \right\}$$

where:

λ - frequency, $0 \le \lambda \le 0.5$,

$\hat{\delta}_m^2$ - the sample variance of the residuals,

$\hat{\phi}_j$ - coefficients from regression $x_t - \bar{x}$ on $x_{t-j} - \bar{x}$, $1 \le j \le m$.

Visual spectral analysis

Criterion of "visual significance" is based on the range $\hat{s}^{\max} - \hat{s}^{\min}$ of the $\hat{s}(\lambda)$ values,

where:

$\hat{s}^{\max} = \max_k \hat{s}(\lambda_k)$,

$\hat{s}^{\min} = \min_k \hat{s}(\lambda_k)$,

$\hat{s}(\lambda_k)$ - k -th value of autoregressive spectrum estimator.

96 Definition taken from: 'X-12-Arima Reference Manual'.

The particular value is considered to be visually significant if $\hat{s}(\lambda_k)$ at a trading day or seasonal frequency λ_k (other than the seasonal frequency λ_{60} = 0.5) must be above the median of the plotted values of $\hat{s}(\lambda_k)$ and must be larger than both neighboring values $\hat{s}(\lambda_{k-1})$ and $\hat{s}(\lambda_{k+1})$ by at least 6/52 times the range $\hat{s}^{\max} - \hat{s}^{\min}$.

For a given series $y_{t,0\le t<T}$, which may contain missing values, the periodogram is computed as follows:
In a first step, the series is standardized:

$$z_t = \frac{y_t - \hat{y}_t}{\sigma(y_t)}$$

In a second step, we compute at the so-called Fourier frequencies $(\omega = \frac{2\pi i}{T}, 0 \le i < \frac{T+1}{2})$ which are the values of the periodogram:

$$\frac{2}{N} \cdot \left| \sum_{t=0, z_t \text{ defined}}^{t<T} z_t e^{i\omega t} \right|$$

where N is the number of non-missing values.

Under the white noise assumption, the values of the periodogram should be asymptotically distributed as a Chi-square with 2 degrees of freedom.

The default frequency td for trading days is computed as follows (for series of quarterly series):

$$n = \frac{365{,}25}{q}, q = 4$$

$$td = \frac{2\pi}{7}\left(n - 7 \cdot \left[\frac{n}{7}\right]\right)$$

Other frequencies correspond to trading days frequencies:

- For monthly series, 2.714 (default = 2.188)
- For quarterly series, 1.292, 1.850, 2.128 (default = 0.280).

10A Revision histories

Revisions are calculated as a difference between the first (earliest) adjustment of an observation computed when that observation is the final period of the time series (*concurrent adjustment,* denotes as $A_{t|t}$) and a later adjustment based on all data span (*most recent adjustment,* denotes as $A_{t|N}$).

In case of multiplicative decomposition the revision history of the seasonal adjustment from time N_0 to N_1 is a sequence of $R^A_{t|N}$ calculated in a following way[97]:

$$R^A_{t|N} = 100 \times \frac{A_{t|N} - A_{t|t}}{A_{t|t}}$$

The revision history of the trend is calculated in a similar way:

$$R^T_{t|N} = 100 \times \frac{T_{t|N} - T_{t|t}}{T_{t|t}}$$

With additive decomposition $R^A_{t|N}$ is calculated in the same way if all values $A_{t|t}$ have the same sign[98]. Otherwise differences are calculated as:

$$R^A_{t|N} = A_{t|N} - A_{t|t}$$

The analogous quantities are calculated for final Henderson trends.

11A Sliding spans

Each period (month or quarter) which belongs to more than one span is examined to see if its seasonal adjustments vary more than a specified amount across the spans[99].

Seasonal factor is regarded to be unreliable if the following condition is fulfilled:

$$SS_t = \frac{\max_{k \in N_t} S_t(k) - \min_{k \in N_t} S_t(k)}{\min_{k \in N_t} S_t(k)} > 0.03,$$

Where:

$S_t(k)$ - the seasonal factor estimated from span k for month t.

N_t = {k : period t is in the k-th span}.

For seasonally and trading days adjusted series the following statistic is being calculated:

97 FINDLEY, D. F., MONSELL, B. C., BELL, W. R., OTTO, M. C., and CHEN, B-C. (1998).

98 'X-12-Arima Reference Manual' (2007).

99 FINDLEY, D. F., MONSELL, B. C., BELL, W. R., OTTO, M. C., and CHEN, B-C. (1990).

$$\frac{\max_j A_t^j - \min_j A_t^j}{\min_j A_t^j}$$

where:

The index j ranges over all spans containing month t .

The value A_t is considered to be unreliable if it is higher than 0.03.

If both period t and $t-1$belobgs to at least two spans, the seasonally adjusted period-to-period percentage changes $\left(\frac{100(A_t - A_{t-1})}{A_{t-1}}\right)$ are marked as unstable if[100]:

$$\max_j \frac{A_t^j}{A_{t-1}^j} - \min_j \frac{A_t^j}{A_{t-1}^j} > 0.03$$

Where:

$A_t(k)$ - the seasonally (or trading day) adjusted value from span k for month t,

$N1(t)$ = {k : period t and $t-1$ are in the k -th span},

The index j ranges over all spans containing month t .

12A Tests

Doornik-Hansen test is defined as follows: let s = skweness, k =kurtosis of the n (non-missing) residuals.

We make the following transformations:

Transformation of the skewness (D'Agostino)

$$\beta = \frac{3(n^2 + 27n - 70)(n+1)(n+3)}{(n-2)(n+5)(n+7)(n+9)}$$

$$\omega^2 = -1 + \sqrt{2(\beta - 1)}$$

100 'X-12-Arima Reference Manual' (2007).

$$\delta = \frac{1}{\sqrt{0.5 \log \omega^2}}$$

$$y = s\sqrt{\frac{(\omega^2 - 1)(n+1)(n+3)}{12(n-2)}}$$

$$z_1 = \delta \log(y + \sqrt{y^2 - 1})$$

Transformation of the kurtosis (Wilson-Hilferty)

$$\delta = (n-3)(n+1)(n^2 + 15n - 4)$$

$$a = \frac{(n-2)(n+5)(n+7)(n^2 + 27n - 70)}{6\delta}$$

$$c = \frac{(n-7)(n+5)(n+7)(n^2 + 2n - 5)}{6\delta}$$

$$l = \frac{(n+5)(n+7)(n+7)(n^3 + 37n^2 + 11n - 313)}{12\delta}$$

$$\alpha = a + c \cdot s \cdot s$$

$$\chi = 2l(k - 1 - s^2)$$

$$z_2 = (\sqrt{9\alpha})\left(\frac{1}{9\alpha} - 1 + \sqrt[3]{\frac{\chi}{2\alpha}}\right)$$

Then the Doornik-Hansen test statistic is defined as the sum of squared transformations of the skweness and kurtosis. Asymptotically the test statistic follows a chi-square distribution.

$$DH = z_1^2 + z_2^2 \sim \chi^2(2)$$

Ljung-Box test

Ljung-Box test is defined as follows:

let ρ_j the sample autocorrelation at rank j of the n residuals. The Ljung-Box statistics is

$$LB(k) = n \cdot (n-2) \sum_{j-1}^{k} \frac{\rho_j^2}{n - j}$$

If the residuals are random, it will be distributed as $\chi^2(k-np)$ where np is the number of hyper-parameters of the model from which the residuals are derived.

Seasonality tests

This section presents the set of seasonality tests calculated by Demetra+. Detailed description of these tests and testing procedure is available in LADIRAY D. and QUENNEVILLE B. (1999).

• Friedman test (stable seasonality test)

Friedman's test is a non-parametric method for testing that samples are drawn from the same population or from populations with equal medians. In the regression equation the significance of the month (or quarter) effect is tested. Friedman test requires no distributional assumptions. It uses the rankings of the observations.

Seasonal adjustment procedures uses Friedman test for checking the presence of seasonality. Friedman test is called a stable seasonality test. This test uses preliminary estimation of the unmodified Seasonal-Irregular component[101] (for X12 this time series is shown in table B3) from which k samples are derived ($k=12$ for monthly series and $k=4$ for quarterly series) of size $n_1, n_2, ...n_k$ respectively. Each k corresponds to a different level of seasonality. It is assumed that seasonality affect only the means of the distribution and not their variance. Assuming that each sample is derived from a random variable X_j following the normal distribution with mean m_j and standard deviation σ the following null hypothesis is tested:

$H_0: \quad m_1 = m_2 = ... = m_k$

against:

$H_1: \quad m_p \neq m_q$ for the least one pair (p,q)

The test uses the following decomposition of the variance:

$$\sum_{j=1}^{k}\sum_{i=1}^{n_j}(x_{i,j}-\bar{x})^2 = \sum_{j=1}^{k} n_j(\bar{x}_{\bullet j}-\bar{x}_{\bullet\bullet})^2 + \sum_{j=1}^{k}\sum_{i=1}^{n_j}(x_{i,j}-\bar{x}_{\bullet j})^2$$

where $\bar{x}_{.j}$ is the average of j-th sample.

The total variance is therefore broken down into a variance of the averages due to seasonality and a residual seasonality.

101 Unmodified Seasonal-Irregular component is the seasonal-irregular factors with the extreme values.

The test statistics is calculated as:

$$F_S = \frac{\frac{\sum_{j=1}^{k} n_j (\bar{x}_{\bullet j} - \bar{x}_{\bullet\bullet})^2}{k-1}}{\frac{\sum_{j=1}^{k}\sum_{i=1}^{n_j} (x_{i,j} - \bar{x}_{\bullet j})^2}{n-k}} \sim F(k-1, n-k)$$

Where $k-1$ and $n-k$ are degrees of freedom.

The number of observations in preliminary estimation of the unmodified Seasonal-Irregular is lower than in final estimation of the unmodified Seasonal-Irregular component. Because of that the number of degrees of freedom in stable seasonality test is lower than number of degrees of freedom in test for the presence of seasonality assuming stability (see 4.4.3) (e.g. X12 uses centered moving average of order 12 to calculate the preliminary estimation of trend-cycle. As a result the first six and last six points in the series are not computed at this stage of calculation. Preliminary estimation of trend-cycle is then used for calculation the preliminary estimation of the unmodified Seasonal-Irregular).

If the null hypothesis of no stable seasonality is not rejected at the 0.10% significance level ($P_s \geq 0.001$), then the series is considered to be non-seasonal.

- **Kruskal-Wallis test**

Kruscal-Wallis test is a non-parametric test used for comparing samples from two or more groups. The null hypothesis states that all months (or quarters, respectively) have the same mean.

The test is calculated for the final estimation of the unmodified Seasonal-Irregular component from which k samples A_j are derived ($k = 12$ for monthly series and $k = 4$ for quarterly series) of size $n_1, n_2, ...n_k$ respectively.

The test is based on the statistic:

$$W = \frac{12}{n(n+1)} \sum_{j=1}^{k} \frac{S_j^2}{n_j} - 3(n+1)$$

where S_j is the sum of the ranks of the observations from the sample A_j within the whole sample of $n = \sum_{j=1}^{k} n_j$ observations.

Under the null hypothesis the test statistic follows a chi-square distribution with $k-1$ degrees of freedom.

- **Test for the presence of seasonality assuming stability**

The test statistics and testing hypothesis are the same as for Friedman stable seasonality test. The test statistics is calculated for final estimation of the unmodified Seasonal-Irregular Component (in case of X12 this series is presented in table D8).

- **Evolutive seasonality test (Moving seasonality test)**

The test is based on a two-way analysis of variance model. The model uses the values from complete years only. For the seasonal-irregular component it uses one of the following models, depending on the decomposition's type:

Multiplicative:

$$\left|SI_{ij} - 1\right| = X_{ij} = b_i + m_j + e_{ij}$$

Additive:

$$\left|SI_{ij}\right| = X_{ij} = b_i + m_j + e_{ij}$$

Where m_j refers to the monthly or quarterly effect for j-th period, $j = (1,...,k)$ where $k = 12$ for monthly series and $k = 4$ for quarterly series,

b_j refers to the annual effect i ($i = 1,..., N$) where N is the number of complete years,

e_{ij} represents the residual effect.

The test is based on the decomposition $S^2 = S_A^2 + S_B^2 + S_R^2$ where:

$S_R^2 = \sum_{i=1}^{N}\sum_{i=1}^{N}(\bar{X}_{ij} - \bar{X}_{\bullet\bullet})^2$ - the total sum of squares,

$S_A^2 = k\sum_{i=1}^{N}(\bar{X}_{\bullet j} - \bar{X}_{\bullet\bullet})^2$ - the inter-month (inter-quarter, respectively) sum of squares,

$S_B^2 = k\sum_{i=1}^{N}(\bar{X}_{i\bullet} - \bar{X}_{\bullet\bullet})^2$ - the inter-year sum of squares,

$S_R^2 = \sum_{i=1}^{N}\sum_{i=1}^{N}(\bar{X}_{ij} - \bar{X}_{i\bullet} - \bar{X}_{\bullet j} + \bar{X}_{\bullet\bullet})^2$ - the residual sum of squares.

The null hypothesis H_0 is that $b_1 = b_2 = ... = b_N$ which means that there is no change in seasonality over the years.

This hypothesis is verified by the following test statistics:

$$F_M = \frac{\frac{S_B^2}{(n-1)}}{\frac{S_R^2}{(n-1)(k-1)}}$$

which follows a F -distribution with $k-1$ and $n-k$ degrees of freedom.

- **Test for presence of identifiable seasonality**

This test combines the values of the F-statistic (of parametric test for stable seasonality) and the values of the moving seasonality test, which was described above.

The test statistic is:

$$T = \left(\frac{\frac{7}{F_S} + \frac{3F_M}{F_S}}{2} \right)^{0.5}$$

Where F_S is a stable seasonality test statistic and F_M is moving seasonality test statistic.

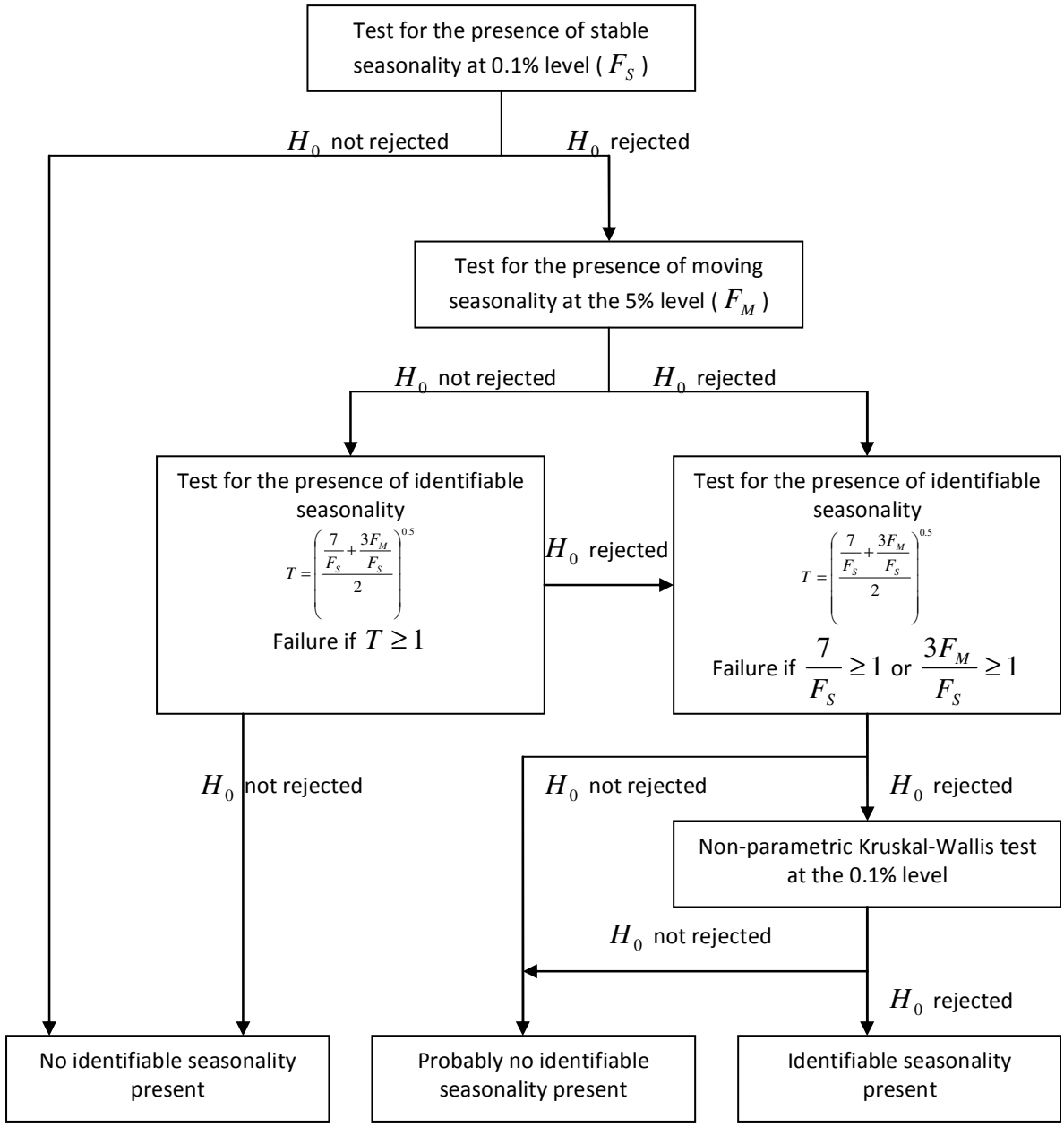
The detailed test's description is available in LOTHIAN J., and MORRY M. (1978).

- **Combined seasonality test**

This test combines the Kruskal-Wallis test along with test for the presence of seasonality assuming stability, evaluative seasonality test and test for presence of identifiable seasonality. All those tests are calculated using the final unmodified S-I component. The main purpose of the combined seasonality test is to check whether the seasonality of the series is identifiable. For example, identification of the seasonal pattern is problematic if the process is dominated by highly moving seasonality[102].

The testing procedure is shown below:

102 DAGUM, E. B. (1987).


Test for the presence of stable seasonality at 0.1% level (F_S)
H_0 not rejected
H_0 rejected
Test for the presence of moving seasonality at the 5% level (F_M)
H_0 not rejected
H_0 rejected
Test for the presence of identifiable seasonality
$T = \left(\frac{\frac{7}{F_S} + \frac{3F_M}{F_S}}{2} \right)^{0.5}$
Failure if $T \geq 1$
H_0 rejected
Test for the presence of identifiable seasonality
$T = \left(\frac{\frac{7}{F_S} + \frac{3F_M}{F_S}}{2} \right)^{0.5}$
Failure if $\frac{7}{F_S} \geq 1$ or $\frac{3F_M}{F_S} \geq 1$
H_0 not rejected
H_0 not rejected
H_0 rejected
Non-parametric Kruskal-Wallis test at the 0.1% level
H_0 not rejected
H_0 rejected
No identifiable seasonality present
Probably no identifiable seasonality present
Identifiable seasonality present

13A Code to generate simple seasonal adjustments (C#)

(Some namespaces have been removed to simplify the reading)

```
// creates a new time series
// parameters: frequency/first year/first period (0-based)/array of doubles/copy
data (uses the current array or creates a copy)
TSData s = new TSData(12, 1967, 0, g_prodind, false);

// basic processing

// tramo-seats specification. RSA5 (full automatic)
TramoSeats.Specification ts_spec =      TramoSeats.Specification.RSA5;

// launches tramo-seats core engine
```

```
TramoSeats.Monitor ts_monitor=new TramoSeats.Monitor();
// executes the processing
TramoSeats.TramoSeatsResults ts_rslts = ts_monitor.Process(s, ts_spec);

// x12 specification. equivalent RSA5 (full automatic)
X12.Specification x_spec = X12.Specification.RSA5;

// launches tramo-seats core engine
X12.Monitor x_monitor=new X12.Monitor();
// executes the processing
X12.X12Results x_rslts = x_monitor.Process(s, x_spec);

// seasonally adjusted series
TSData ts_sa = ts_rslts.Series(SAComponentType.CSA);
TSData x_sa = x_rslts.Series(SAComponentType.CSA);

// computes diffrences between both results...
TSData diff = ts_sa - x_sa;

// computes statistics on the differences...
DescriptiveStatistics stats = new DescriptiveStatistics(diff.Values);

double max = stats.Max, min = stats.Min, rmse = Math.Sqrt(stats.SumSquare /
diff.Length);

// more advanced uses (computed "on the fly")
Periodogram periodogram = new Periodogram(x_rslts.X11Results.DTables["D8"]
       .Values);

// roots of the moving average polynomial of the arima model used by Seats
Complex[] roots = ts_rslts.Seats.SArima.MA.Roots();
```

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